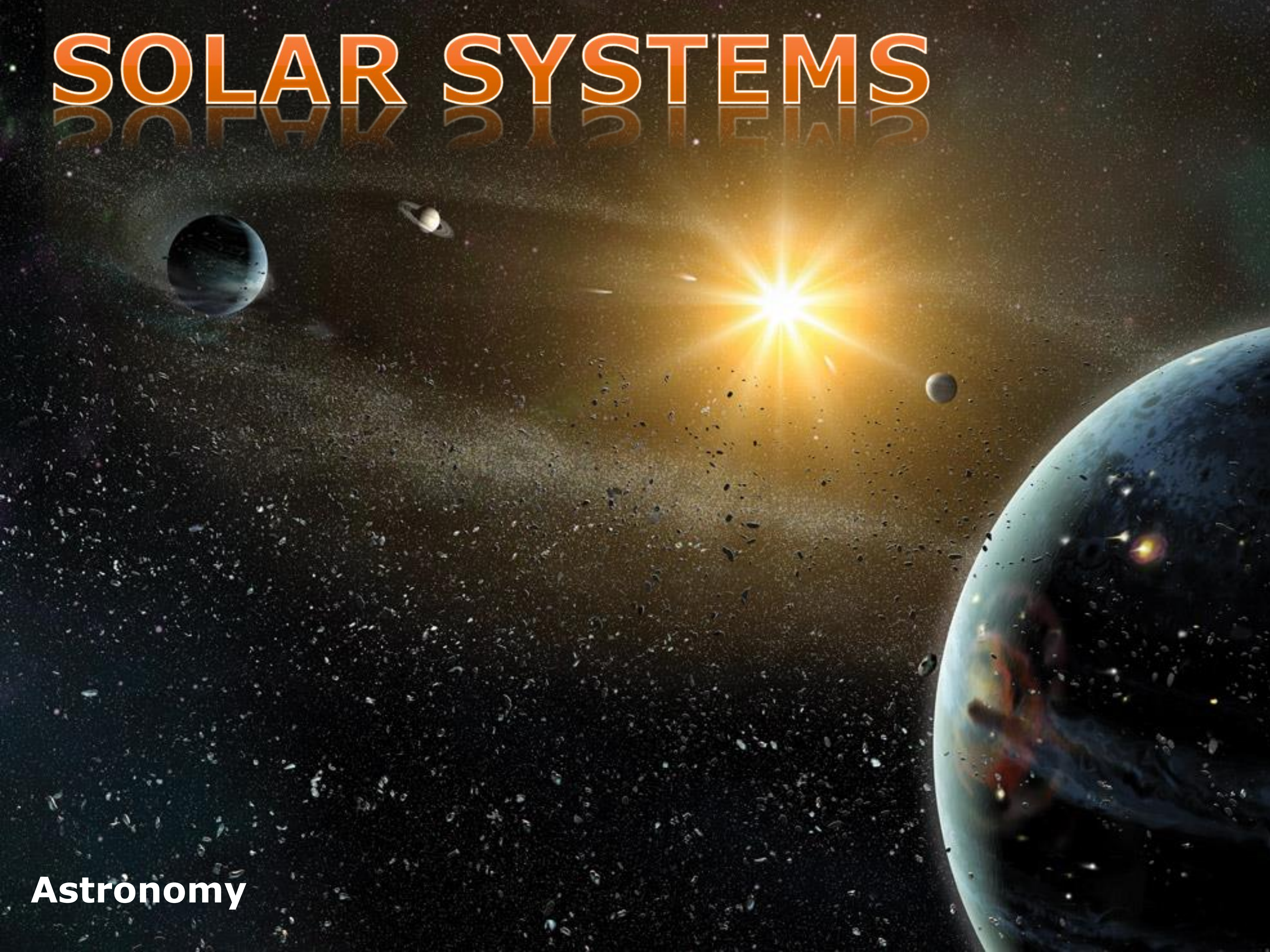
SOLAR SYSTEMS



Astronomy

Introduction

Sections:

- Components of the Solar System
- Formation of Planetary Systems
- Other Planetary Systems

Components of the Solar System

The Sun

- The Sun is a star
- Star – ball of _________ gas whose light and heat are generated by _________ reactions in its core
- It's the largest _________ in the solar system
  - More than 700x the mass of the other objects put together
  - Its gravitational force holds the other planets in place
- Solar System – the _________ domination of the planets by the Sun

Components of the Solar System

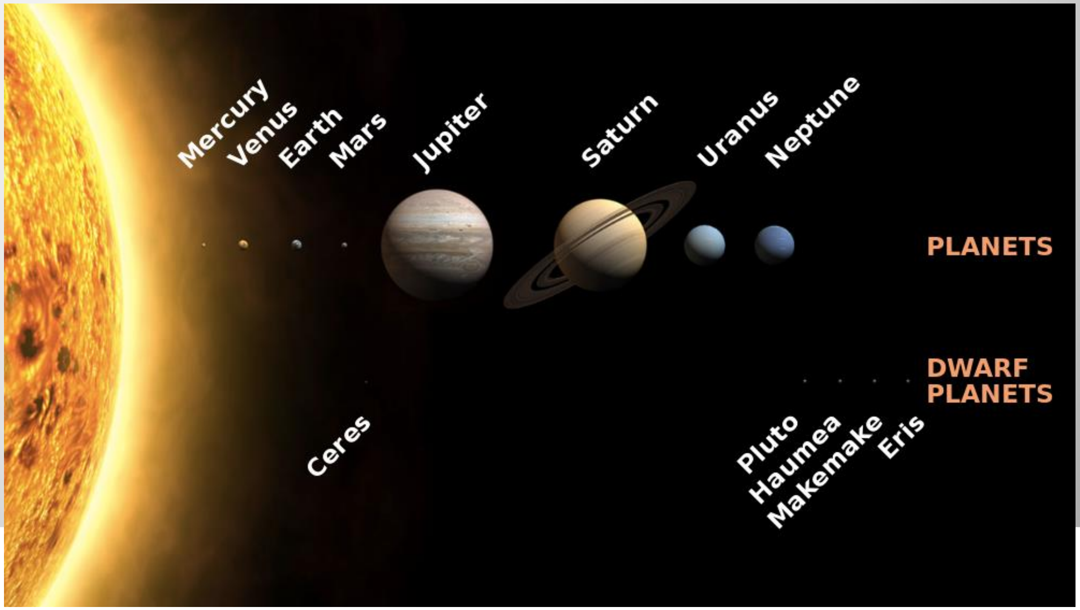
The Sun

- Mostly hydrogen and helium
  - About ________ % H
  - About ________ % He
- Contains small components of:
  - Carbon
  - Iron
  - ________
    - All in a ________ form!
    - We can tell based off of the spectrum of light it emits

Components of the Solar System

The Orbits and Rotations of the Planets

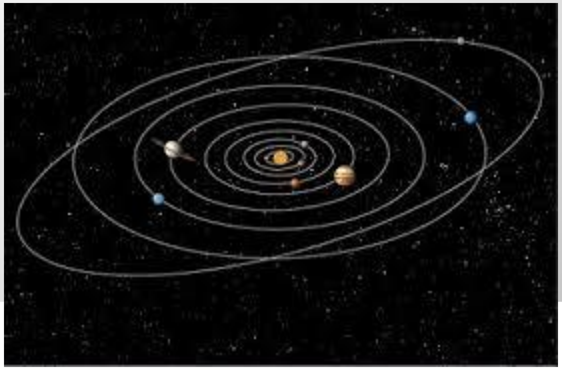
- Planets are much _________ than the Sun
- They emit no _________ light of their own
  - They do shine by reflecting the Sun's light
- Planets in order:
  - __________
  - __________
  - __________
  - __________
  - __________
  - __________
  - __________
  - __________



Components of the Solar System

The Orbits and Rotations of the Planets

- The _________ of all of the planets around the Sun are mostly _________ and almost about the same plane, _________
  - It almost looks like a spinning pancake with the planets traveling around the Sun in the same direction
- The planets' rotation around the sun is _________



Components of the Solar System

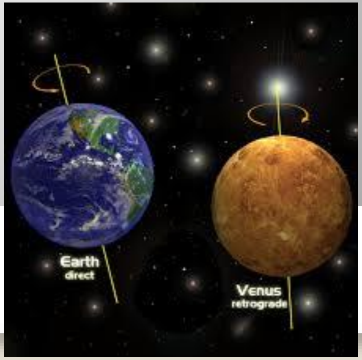
The Orbits and Rotations of the Planets

- As the planets orbit, each "__________ " on its rotation axis
  - The angle of the tilt has to do with how far off of the horizontal plane it is
- Generally, this __________ is in the same direction as the orbit around the Sun
- 2 exceptions to this:
  - _________
  - _________

Components of the Solar System

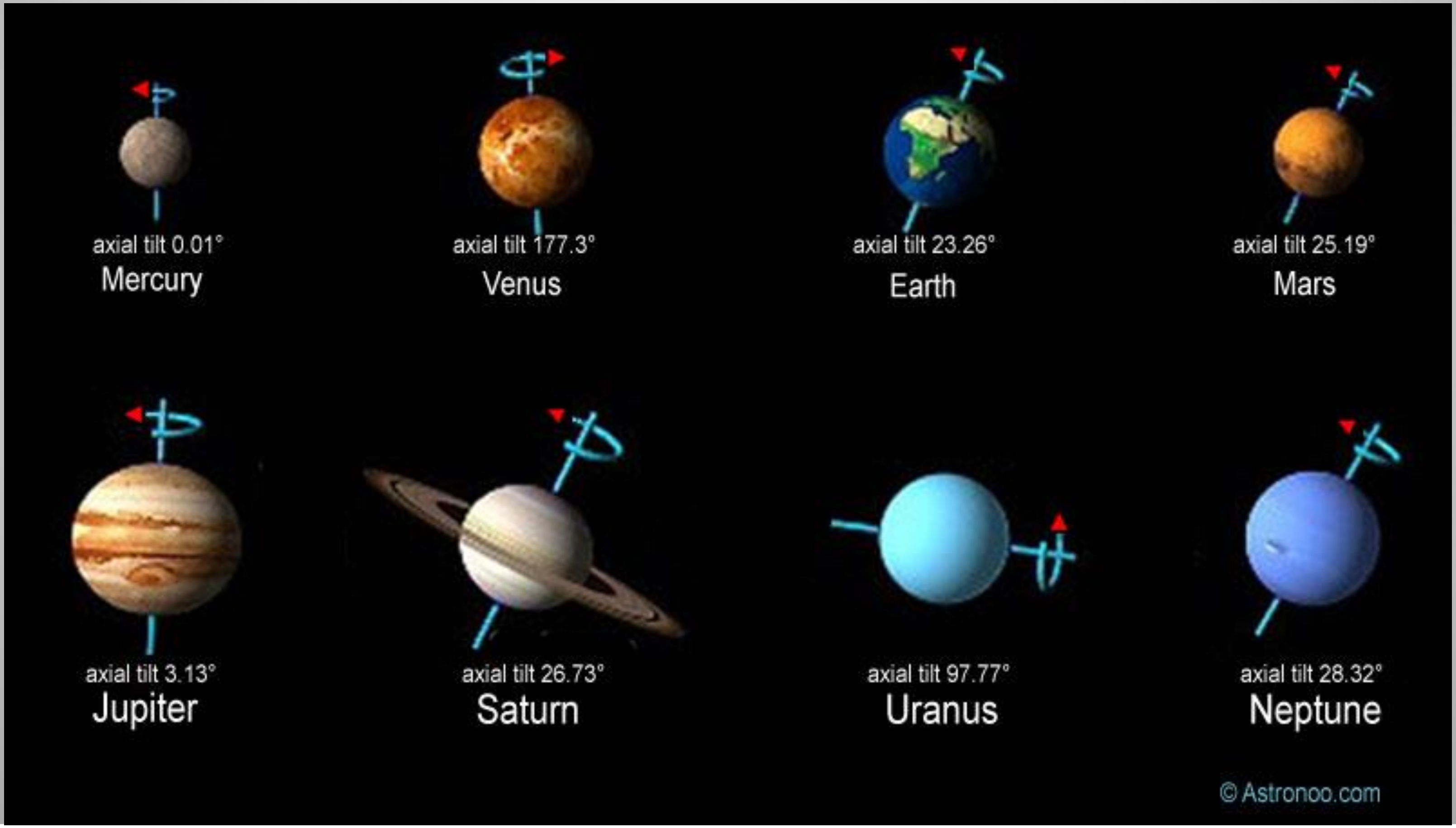
The Orbits and Rotations of the Planets

- ________ has an extremely large tilt to its rotation axis (________ °)
- ________ rotation axis has such a large tilt that it actually spins backwards (_______°)
  - Still orbits in the same direction as the others around the Sun
- ________ rotation – when a planet's rotation axis is so steep that it spins backwards



Components of the Solar System

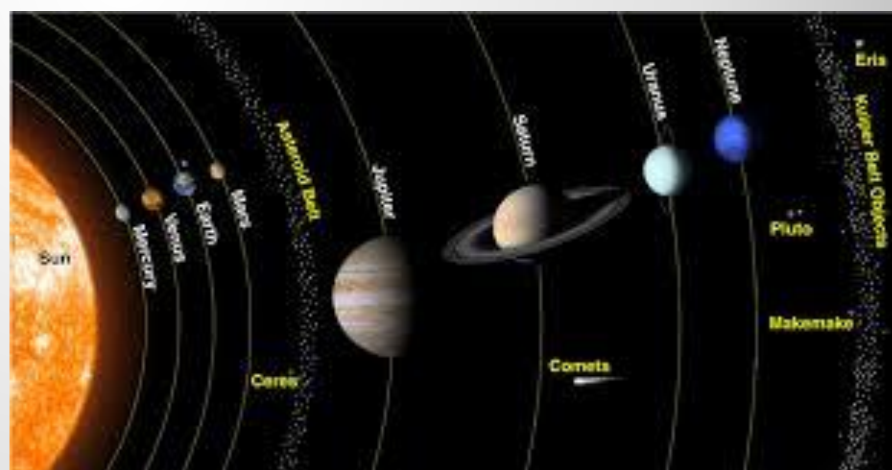
The Orbits and Rotations of the Planets



Components of the Solar System

The Orbits and Rotations of the Planets

- These two _________ (same _________ orbit and flat _________) are the most fundamental features of the Solar System
- A third factor is that there are two different types of planets:
  - ________
  - ________



- Based on :
  - Size
  - ________
  - Location in the Solar System

Components of the Solar System

Two Types of Planets

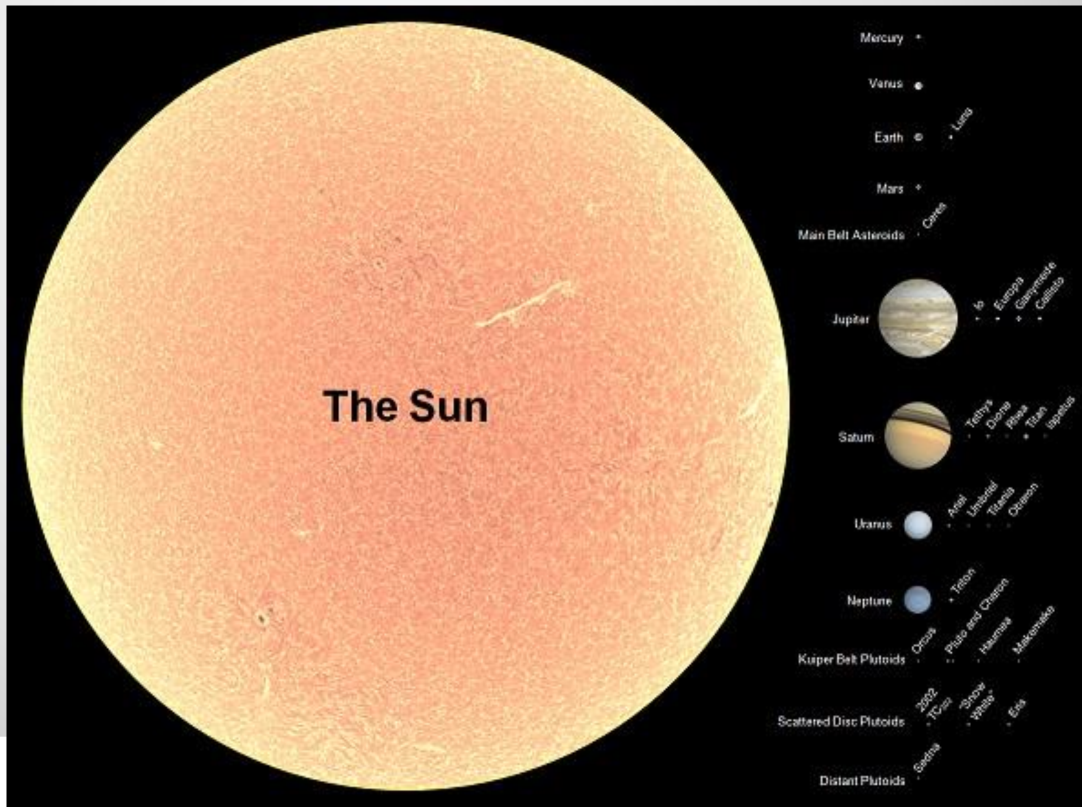
- Inner Planets – _________ , _________ bodies with relatively thin or no atmospheres
  - Mercury
  - ________
  - Earth
  - ________

- Outer Planets – _________ and liquid planets that are much _________ and have deep, _________ atmospheres
  - Jupiter
  - ________
  - Uranus
  - ________

Components of the Solar System

Two Types of Planets

- Jupiter is more than ________ larger in diameter than the Earth and has ________ its mass



Components of the Solar System

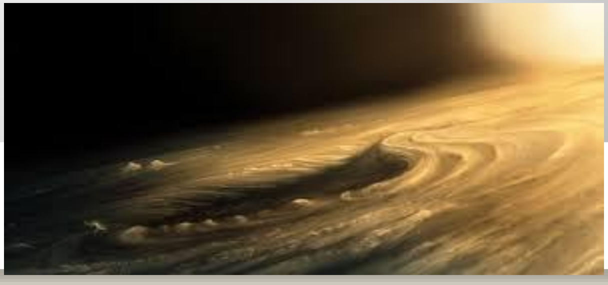
Two Types of Planets

- _________ and _________ are how we describe the planets
- Rock – material composed of silicates
  - Silicates – composed of ________ , O, and other heavier elements like Al, Mg, S, and Fe
- Ice – frozen liquids and gases
  - Such as:
    - Regular ________ (H_2O)
    - Frozen ________ dioxide (CO_2)
    - Frozen ________ (NH_3)
    - Frozen ________ (CH_4)

Components of the Solar System

Two Types of Planets

- Looking at the _________ solar system, rock is _____because of the amount of hydrogen
  - Because of the heat near the sun, the carbon dioxide, methane, water, and ammonia can't condense to mingle with it
- The outer planets have no "_________ "
  - Their ________ thicken with depth and eventually convert to liquid
  - Therefore we can't "________ " on Jupiter or the other outer planets



Components of the Solar System

Two Types of Planets

- _________ Planets – Mercury, _________ , Earth, and Mars
  - Because they resemble ________
- _________ Planets – Jupiter, _________ , Uranus, and Neptune
  - Because they resemble ________

Components of the Solar System

Two Types of Planets

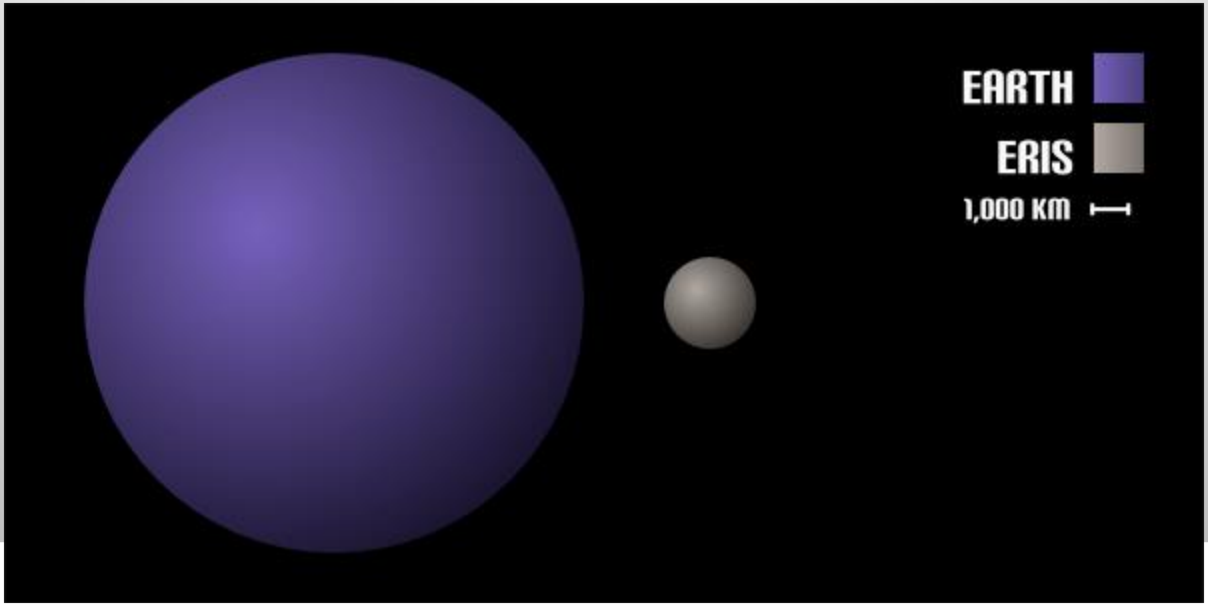
- Why no _________ ?
  - Made if _________ and _________
  - Odd _________
  - Super _________ in comparison

- Astronomers found others similar to it
- Dwarf Planets – objects that orbit the _________ , are massive enough that their _________ compresses them into an approximately spherical shape, but have not swept their orbital region clear of other objects that add up to a comparable mass as the _________

Components of the Solar System

Two Types of Planets

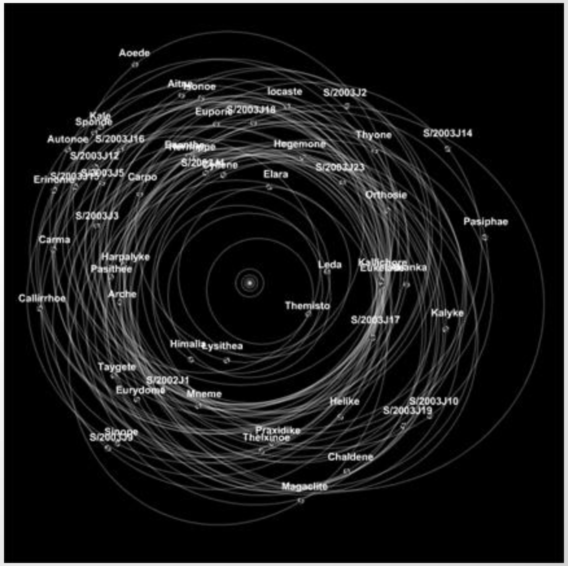
- The discovery of _________ in _________ is what set the demotion of _________
  - Its closer than Pluto and also larger in size, but still fits the ________ planet criteria



Components of the Solar System

Moons

- As the planets orbit the Sun, most are orbited by other ________
- Moons:
  - Jupiter: ________
  - Saturn: ________
  - Uranus: ________
  - Neptune: ________
  - Mars: ________
  - Earth: ________



- Even dwarf planets can have moons
  - Ex: Eris has ________

Components of the Solar System

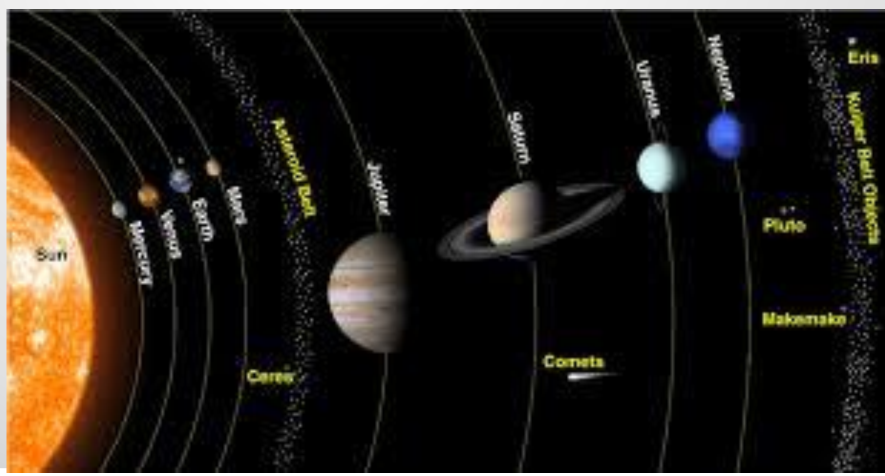
Asteroids and Comets

- Asteroids and comets are far ________ than ________ objects
- Asteroids – ________ or ________ objects with diameters that range from few meters up to about 1000 km
- Comets – ________ objects about 10 km or less in diameter that grow huge tails of gas and dust as they near the Sun and are partially ________ by heat

Components of the Solar System

Asteroids and Comets

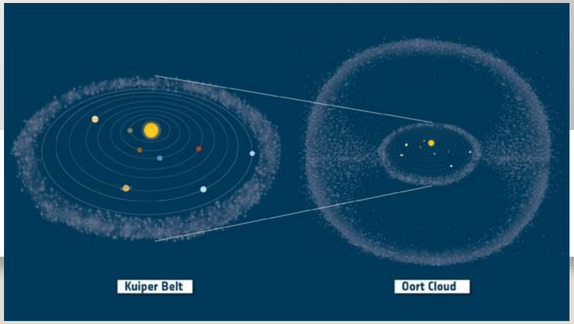
- These two are not only different in _________ but also their _________ in the solar system
- Asteroid Belt – large _________ between the orbits of _________ and Jupiter where asteroids orbit the Sun



Components of the Solar System

Asteroids and Comets

- Most comets orbit far beyond Neptune
- Oort Cloud – _________ region that completely _________ the solar system
  - Extends from about 40,000 to 100,000 AU from the Sun
  - Some can come closer
- Kuiper Belt - the disk-like _________ of icy objects that lies just beyond the _________ of _________ and extends to be about 50 AU from the Sun



Components of the Solar System

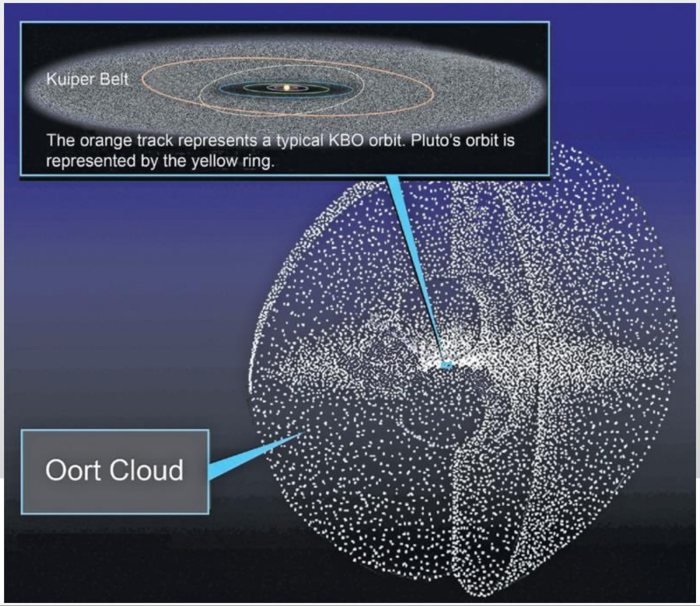
Composition – Inner and Outer Planets

- We can detect a planet’s _________ a couple different ways
- Using its _________ , we can measure its atmospheric composition and get some info about its _________ rocks (if they’re there)
- We use _________ waves to tell us about Earth’s interior and even though we haven’t been able to do that with the other rock planets yet, it would tell us a lot of _________

Components of the Solar System

Asteroids and Comets

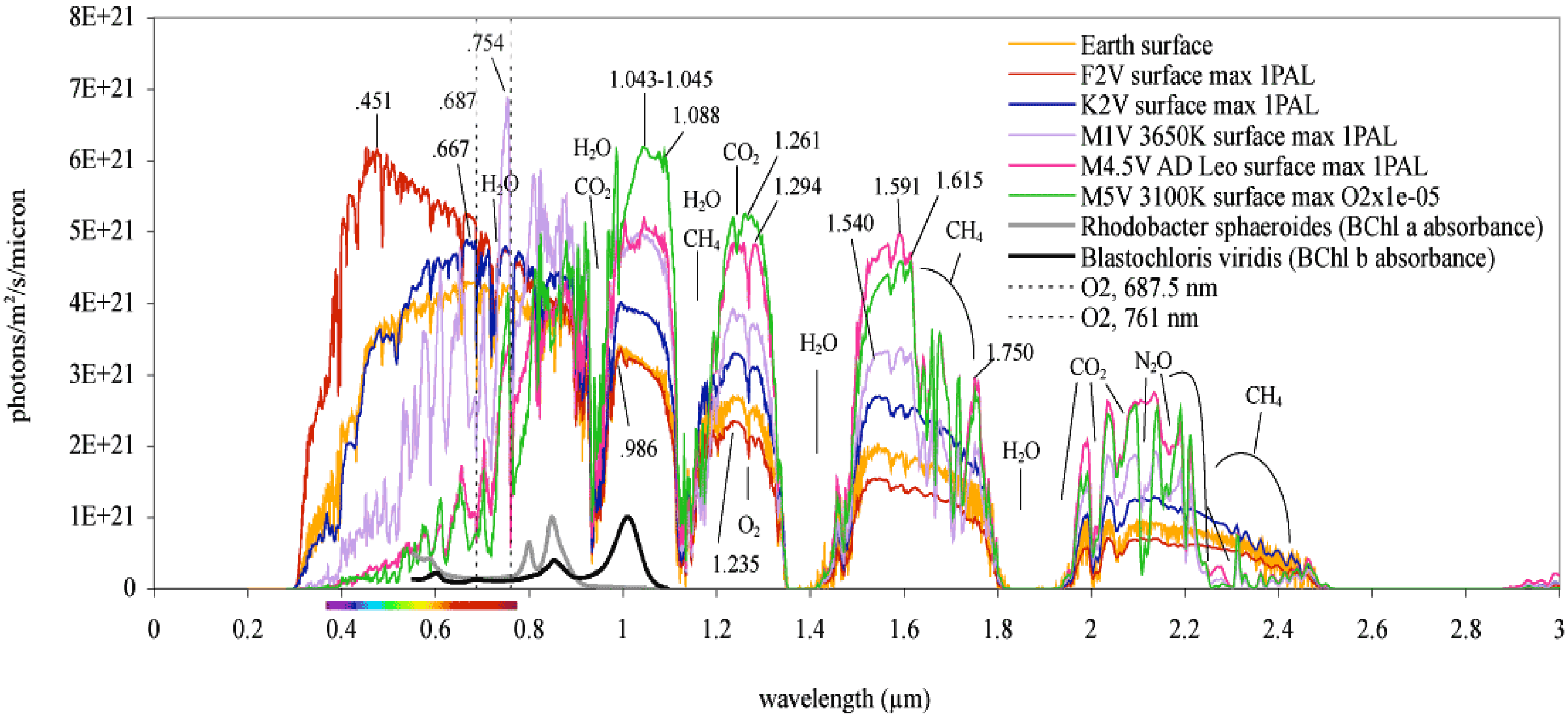
- The __________ cloud and __________ put together can hold:
  - more than 1 ________ ($1x10^{12}$) comets
  - thousands of ________ objects
  - Several dozen dwarf planets – including ________



Components of the Solar System

Composition – Inner and Outer Planets

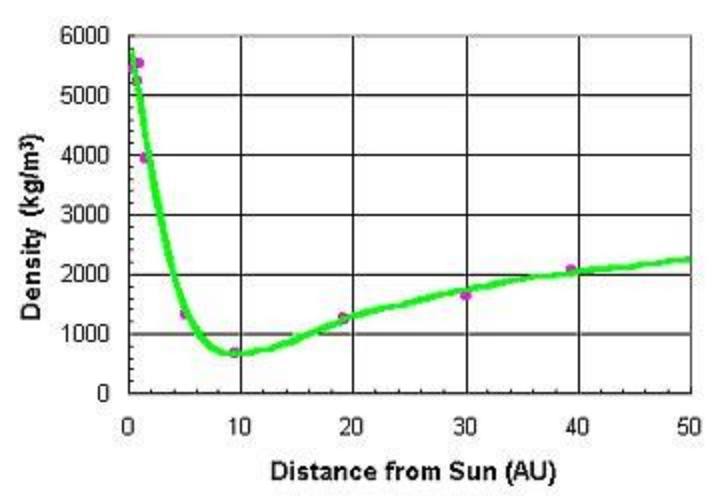
- Earth – detected by ________ and simplified by ________



Components of the Solar System

Composition – Inner and Outer Planets

- For _________ planets, we can't use any type of _________ work and the spectrum only takes care of the surface and atmosphere
- The simplest _________ to use is planetary _________



Components of the Solar System

Planetary Density

- The average _________ of a planet is its mass divided by its _________
  - We can _________ a planet's mass by observing the orbital motion of one of its moons or a passing spacecraft
  - Then we can calculate the volume of the planet using one of Kepler's formulas from his third law

$V =$ _________ $M =$ _________

Components of the Solar System

Planetary Density

- Volume
  - Variable:
    - *R* – ________ of the planet

$V =$ _____

- Mass
  - Variables:
    - *d* – ________ of object from the planet
    - *G* – ________ constant
    - *P* – ________ period

$M =$ ________

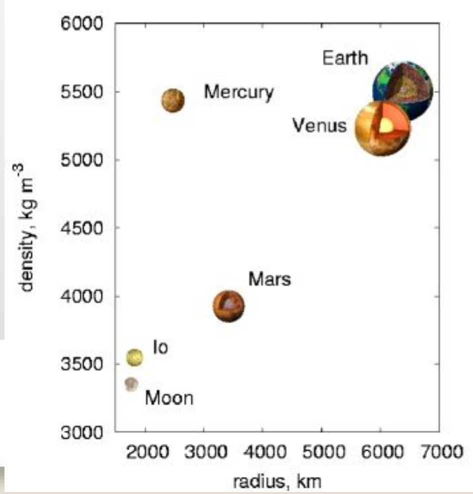
- Density

$D =$ _____

Components of the Solar System

Planetary Density

- Once the planet's _________ density is known, we can compare it with the density of the _________ , _________ materials to find what would _________ match up!
  - We figured this out using Earth's density, calculating the silicate and ________ densities and cross comparing them with the ________ waves… it worked!



Components of the Solar System

Planetary Density

- _________ of this strategy:
  - Several different _________ that will produce an equally good match to the observed density
  - The _________ of a given material can be affected by the planet's _________ force
- Conclusion:
  - All of the _________ planets have a similar density to _________ (about 3.9 to 5.5 g/cm^3)
    - Largely rock with ________ core

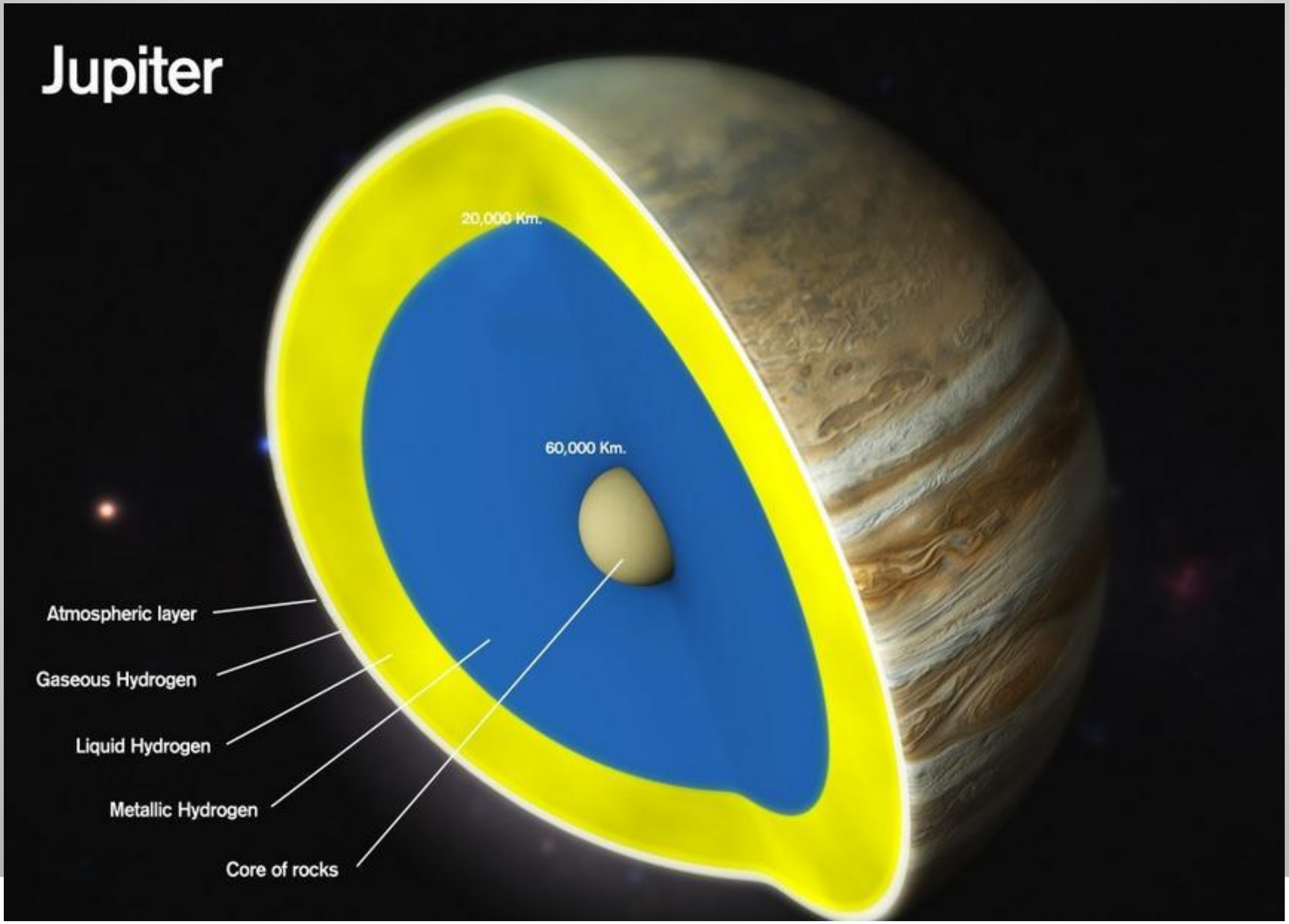
Components of the Solar System

Planetary Density

- Conclusion
  - All of the ________ planets have a much smaller ________ (.7 to 1.7 g/cm^3) – similar to ice
    - Contain mainly methane, ammonia, and ice (H_2O)
  - Probably have an ________ core and ________ base the size of Earth on the inside
    - This was figured out based on the mass calculations and the effects of gravitational pull that these planets can create
    - Jupiter – estimated core ________ the mass of Earth… something solid has to be there…

Components of the Solar System

Planetary Density

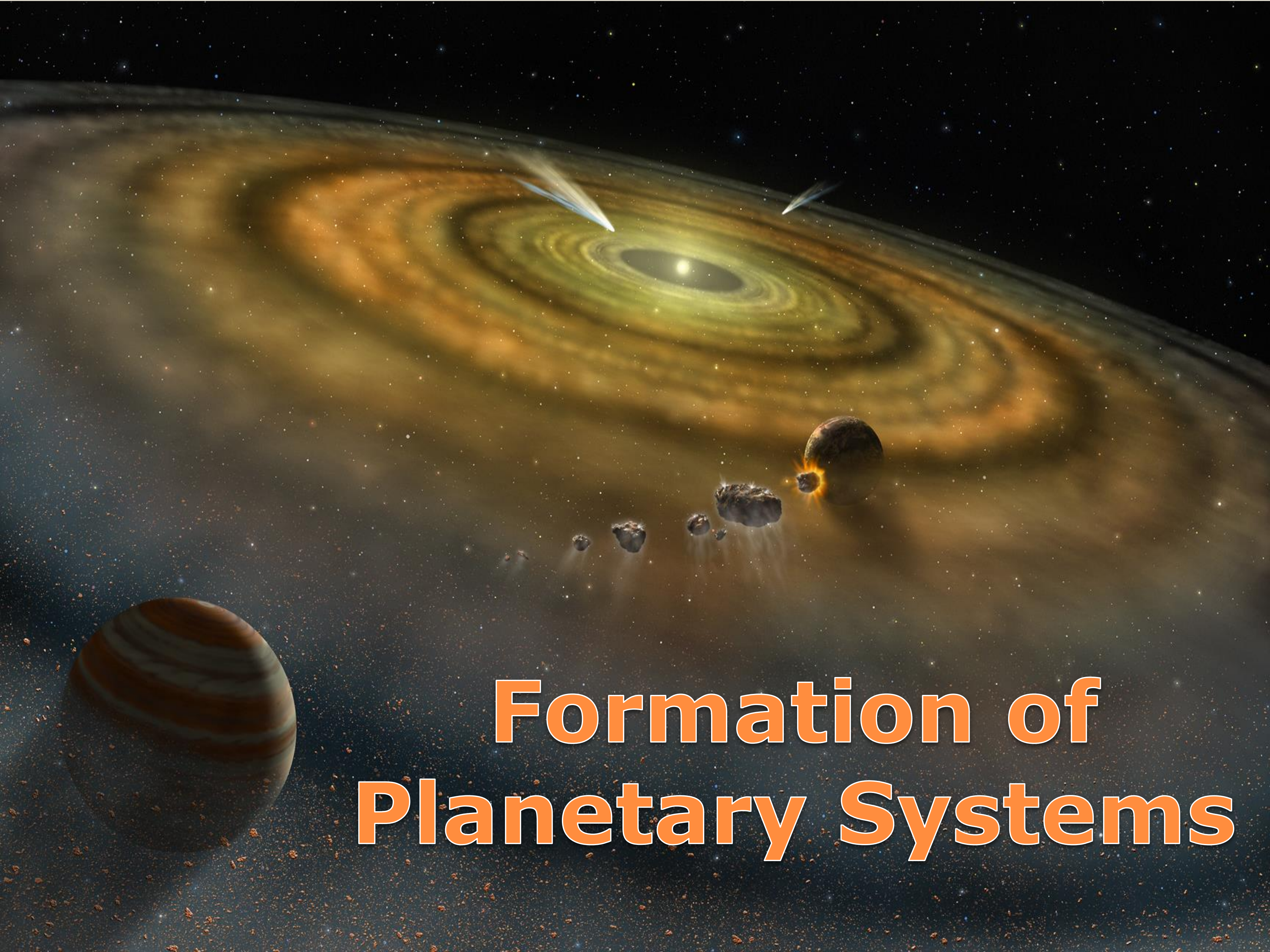


Components of the Solar System

Age of the Solar System

- Outside of their differences in ________ , ________ , and ________ , it seems as though almost everything in the solar system formed at nearly the same time
- We can directly measure that date for the Earth, ________ , and some asteroids
  - Thanks to ________ of their rocks
  - None are more than 4.6 billion years old
- The ________ is our age, too
  - Based off of its current brightness, temp., and rate of nuclear fuel consumption

Formation of Planetary Systems



Formation of the Solar Systems

Introduction

- __________ easy to figure out…
  - Why? We weren’t there to _________ it
- Whatever we come up with has to support these __________ of the solar system:
  - The system is _________ , with all of the planets orbiting the same _________
  - There are two types of planets, _________ and _________
    - With the inner being rock and outer being ice and gas
  - The _________ of the outer planets isn’t too far off of the _________ , and the same is true for the inners (minus the gas)
  - All of the _________ whose ages have so far been determined are younger than 4.6×10^9 _________ old

Formation of the Solar Systems

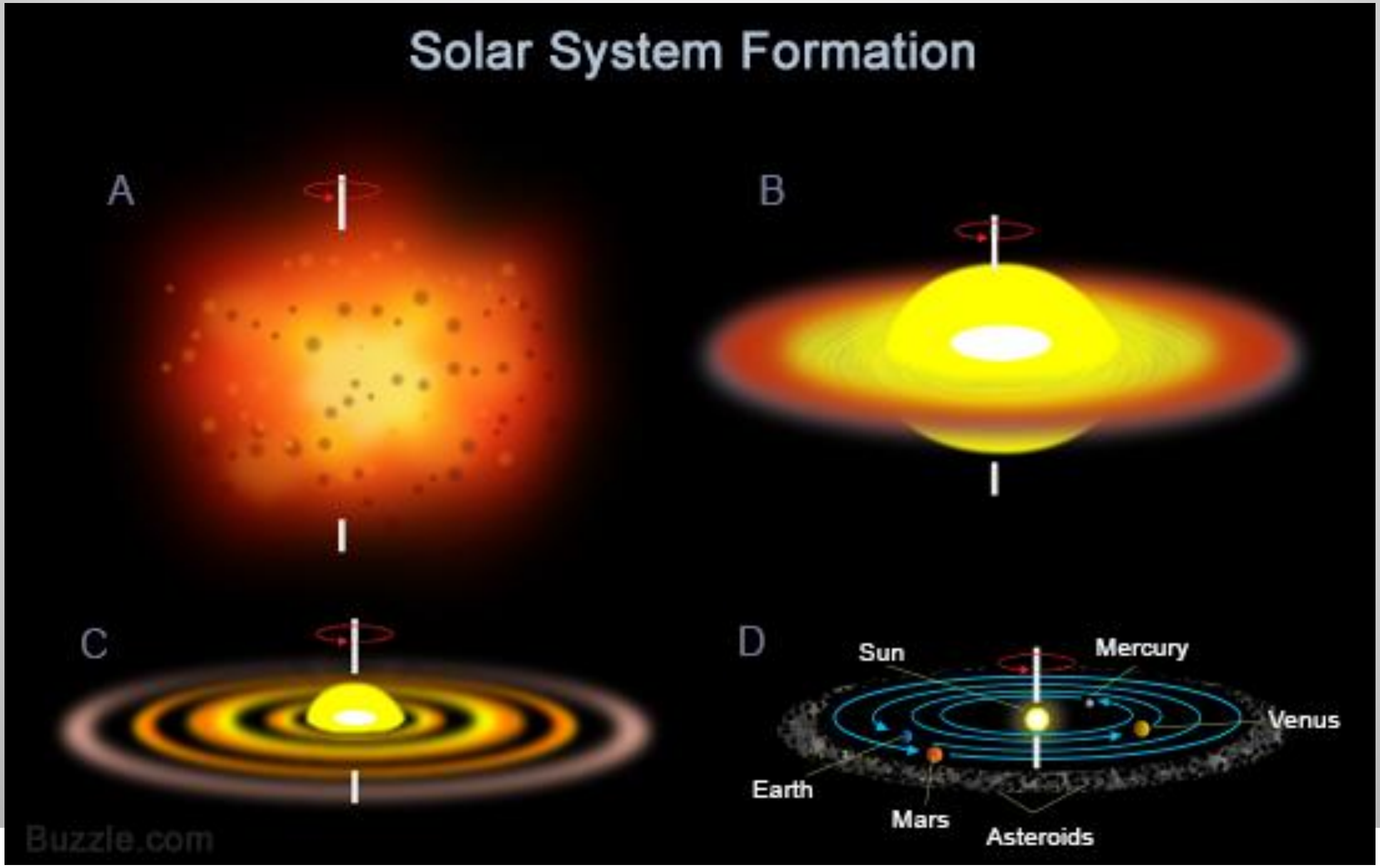
Introduction

- Top theory: _________ _________ Theory
  - States that the ________ system originated from a ________ , flattened ________ of gas and dust, with the outer part of the disk becoming the planets and the center becoming the ________
    - Supports: the horizontal plane and the counterclockwise orbit of all of the planets
- We _________ that if there are other solar systems out there that could be similar to ours, their properties must be _________

Formation of the Solar Systems

Introduction

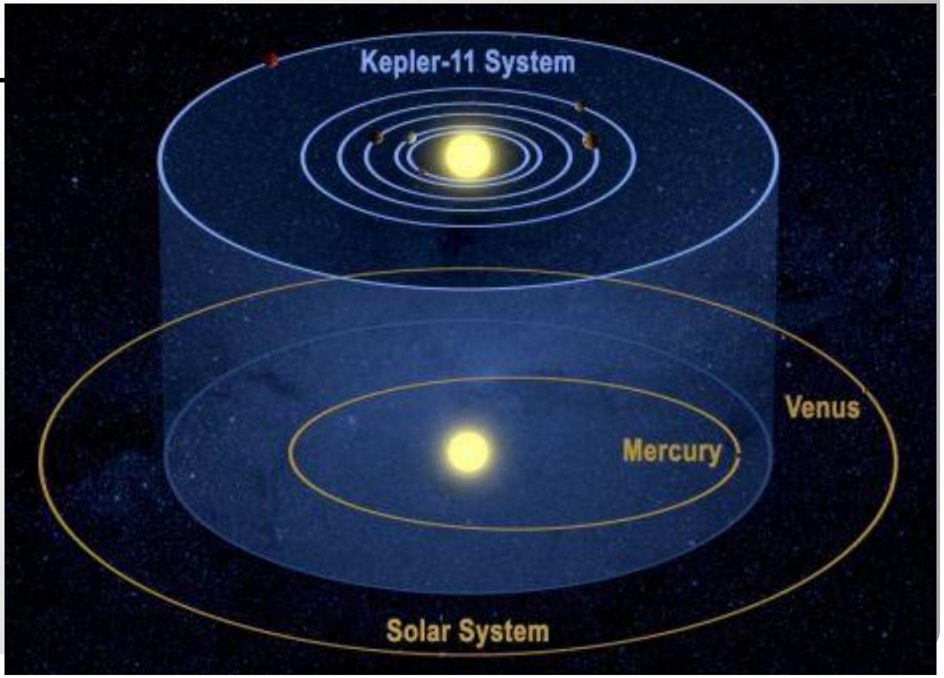
- Top theory: Solar Nebula Theory



Formation of the Solar Systems

Introduction

- Top theory: Solar Nebula Theory
- We are searching for and ________ other ________ in various stages to see if these stages are ________



Formation of the Solar Systems

Interstellar Clouds

- Interstellar Cloud – _________ rotating _________ (whole combo) of _______ and dust
  - Common between stars and astronomers believe these are what developed into each of the stars
  - Right now, ________ stars could have planets orbiting them… we have no way to know for sure right now
    - Both the stars and the planets would have developed from that dust and gas

Formation of the Solar Systems

Interstellar Clouds

- The cloud that developed into the _________ was probably every bit of a couple light years in _________ and twice the present mass of the _________
- Interstellar Grains – tiny dust particles found amongst the _________ in interstellar clouds
  - Combo of: _________ , iron, _________ , and frozen _________
  - These elements have been shown in the same proportions of the Sun according to the Sun's _________

Formation of the Solar Systems

Interstellar Clouds

- The cloud began _________ into the Sun and planets when the gravitational attraction between the _________ in the _________ parts of the cloud caused it to collapse inward
  - Could've been triggered by a star ________ nearby or hitting into another cloud
  - Because the cloud was ________ , it became flat rather than fully collapsing in the middle

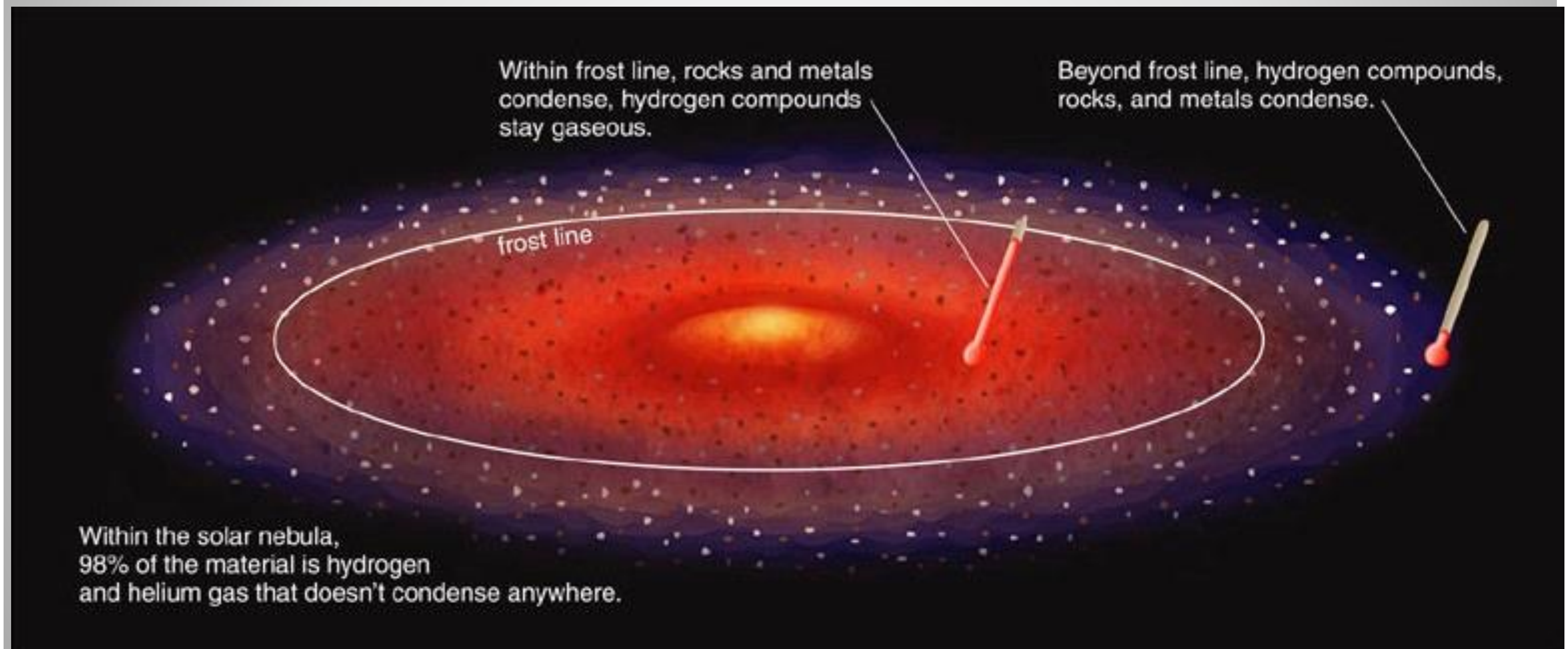
Formation of the Solar Systems

Formation of the Solar Nebula

- Solar Nebula – rotating ________ with a ________ at the center from a collapsing ________ cloud
  - Took a few ________ years to occur
  - Condensed into the planets while the bulge became the sun
  - This supports the disk-like structure and the orbit pattern of the planets
  - Probably about ________ AU in diameter and ________ 10 AU thick
  - Some areas were ________ hot (especially the center) while others were well below the freezing point
  - We have been able to figure this out thanks to the Hubble and seeing the same set-up with other stars

Formation of the Solar Systems

Formation of the Solar Nebula



Formation of the Solar Systems

Condensation in the Solar Nebula

- Condensation – occurs when a gas _________ and its molecules stick _________ to form a liquid or solid
  - There was an entire _________ sequence in the solar nebula as it cooled after collapsing
  - The _________ heat could only reach so far and that division in condensation created the inner and outer planets
    - The silicate-iron particles in the inner part
    - Similar _________ part but with _________

Formation of the Solar Systems

Accretion and Planetesimals

- Accretion – when tiny _________ that condensed from the _________ must have begun to stick _________ into bigger pieces
  - This eventually created the planetesimals
- Planetesimals – small _________ bodies
  - Perhaps held together by electrical forces like static electricity
  - _________(that weren't too crazy) allowed particles to stick together, too
  - Range in size from a few ________ to km

Formation of the Solar Systems

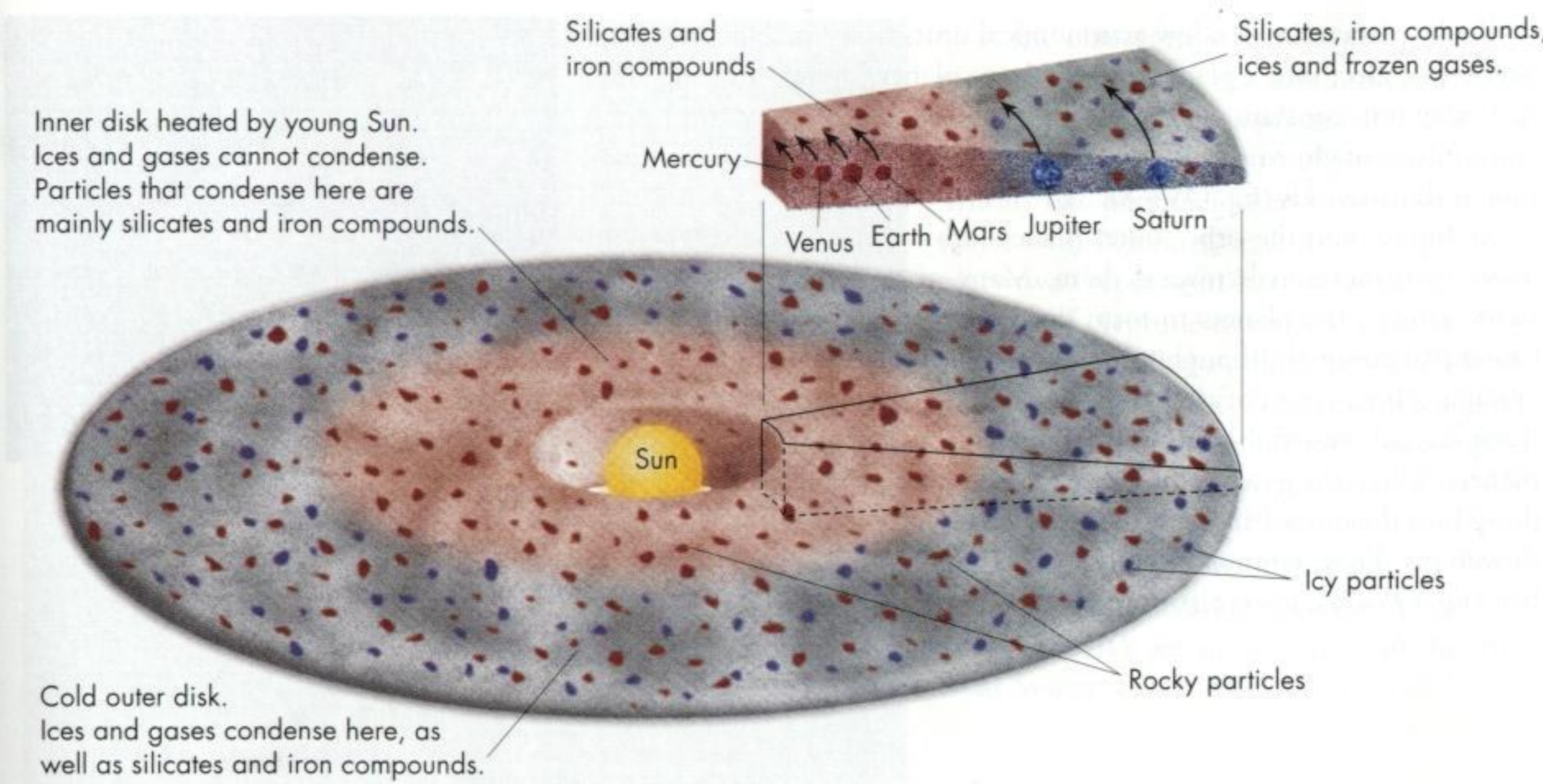


FIGURE OV4.6
Heat from the young Sun prevented ice from condensing in the inner parts of the Solar Nebula. The planetesimals—and ultimately the planets—that formed there are therefore composed mainly of rock and iron.

Formation of the Solar Systems

Formation of the Planets

- As the planetesimals moved within the _________ and _________ , planets began to form
  - Some hit and _________ while others that collided more gently stuck together
  - Due to gravity, substances found in certain areas of the _________ and other chemical factors (like _________) it has been concluded that these collisions are what lead the outer planets to be so much larger than the _________ ones
  - Almost all of the planets _________ like Earth, but the inner planets couldn't hold the gas layers like the outers and therefore they became much larger in volume

Formation of the Solar Systems

Formation of Satellite Systems

- The satellite systems include the _________ and other materials that orbit _________
  - This developed once the _________ was able to develop a larger _________ , strong enough to begin attracting other objects to itself
  - Many of the satellites (moons) are about as large as Mercury and would be considered _________ if they orbited the sun rather than another planet

Formation of the Solar Systems

Formation of the Atmospheres

- Last part of the _________
- _________ and outer planets are thought to have formed _________ differently
  - Outer: captured the ________ from the nebula
  - Inner: not ________ enough and too hot to capture the gas from the nebula
    - Likely created their own from ________ and by retaining gases from ________ comets and icy planetesimals that vaporized on contact

Other Planetary Systems

Other Planetary Systems

Introduction

- Exoplanets – _________ orbiting _________ other than the Sun
  - Studying other planets helps us better understand how our solar system ________
  - Most present ________ for exoplanets comes from their effect on the star they orbit
    - The planet exerts a gravitational force back on the star as a result of Newton's third law (action-reaction)
    - This causes the star to wobble which creates a ________ shift in the spectra that we can measure

Other Planetary Systems

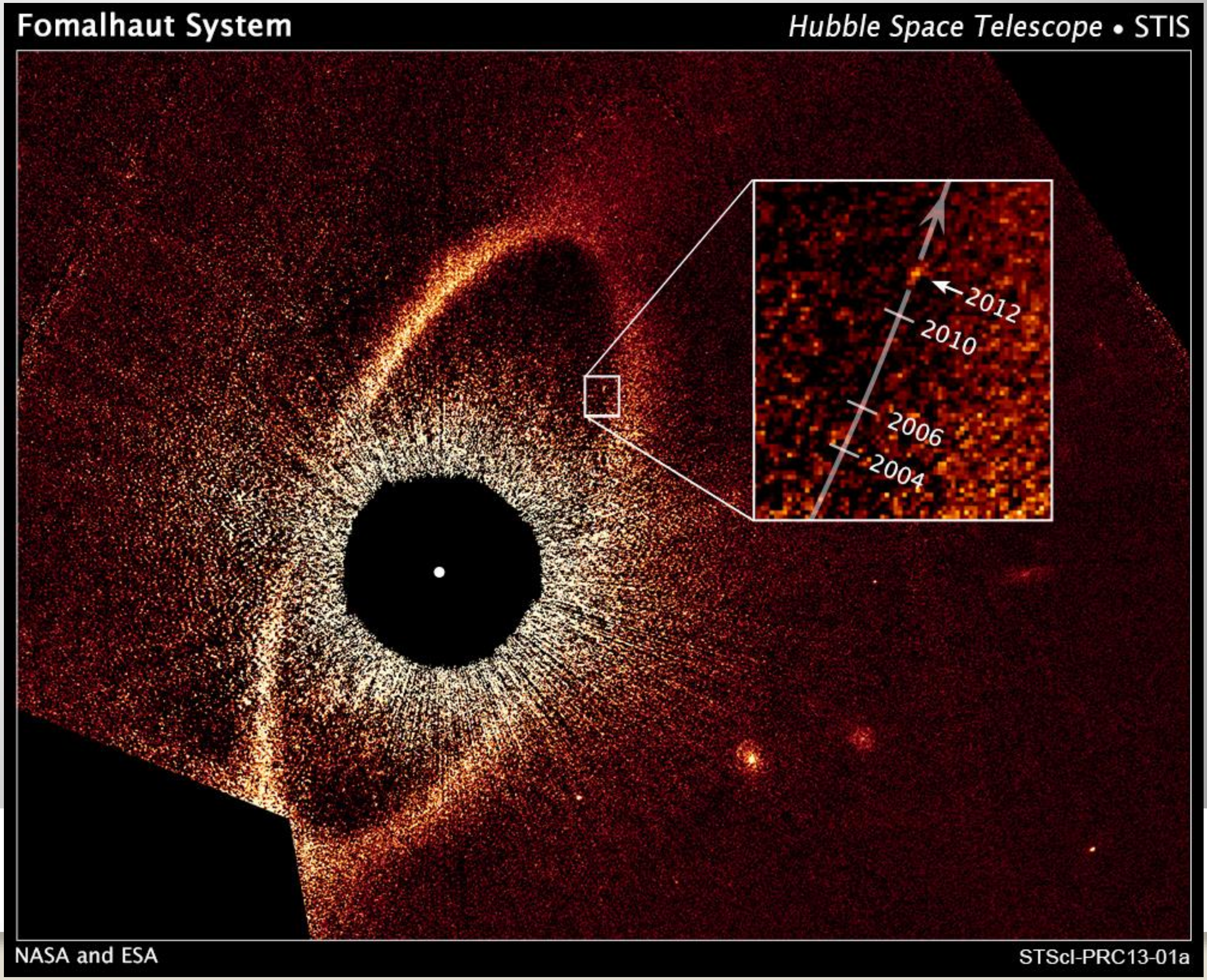
Introduction

- Fomalhaut – a star with a ________ exoplanet
  - Estimated to be a ________ million year old star
  - Has an ice ________ around it (similar to Kuiper's belt)
  - The planet is assumed to have been ________ by accreting that frozen material
  - The exoplanet is really faint and hard to see against the star's light, but the evidence from the star, itself, tells us a lot about that exoplanet

Other Planetary Systems

Introduction

- Fomalhaut – a star with a detected exoplanet

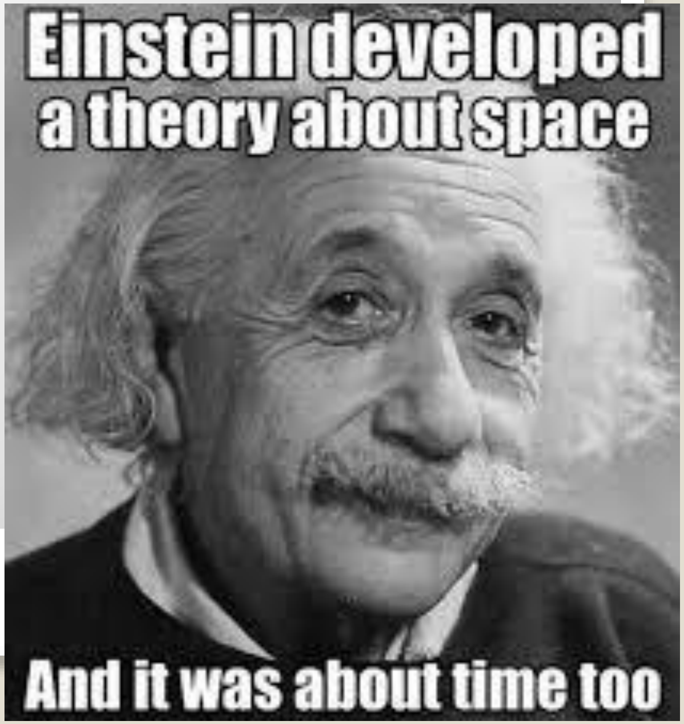


Other Planetary Systems

Finding Exoplanets

- Many of the objects we pick up on are _________ in size and close to their _________
- This allows us to pick up on that Doppler signal since most are hardly _________ , even being large in size
- Another idea…

  use _________ approach

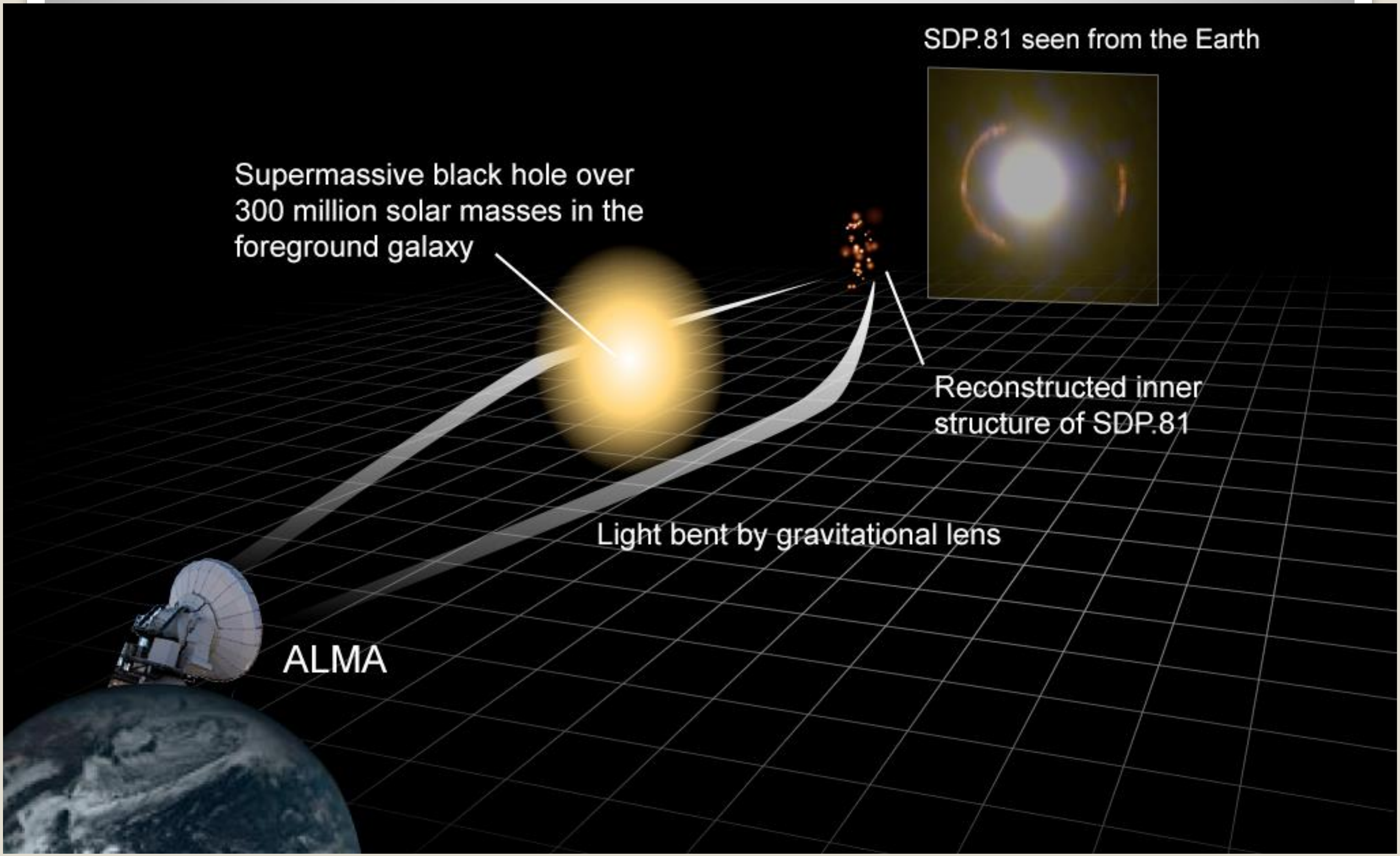


Other Planetary Systems

Einstein's Approach

- He showed that a mass _________ space in its _________ and that this bending creates the mass's gravity
  - Part of his general theory of ________
- If a _________ of light passes near a mass, the bent space around the mass deflects the light and can bring it to a _________

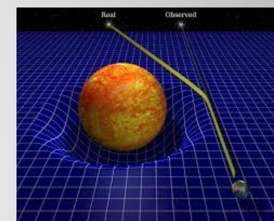
Other Planetary Systems



Other Planetary Systems

Einstein’s Approach

- Gravitational Lensing – _________ of light by gravity
  - Great tool for detecting ________ planets
  - How it works:
    - Measure a star’s _______
    - If a planet crosses in between, its mass will bend the light and because of reflection actually focus more light our way (it’s not much more, but hey, any little bit helps)



- Astronomers are running _________ of data screens on _________ of stars to detect any slight _________ in that brightness level that might suggest a planet or big body that would be present

Other Planetary Systems

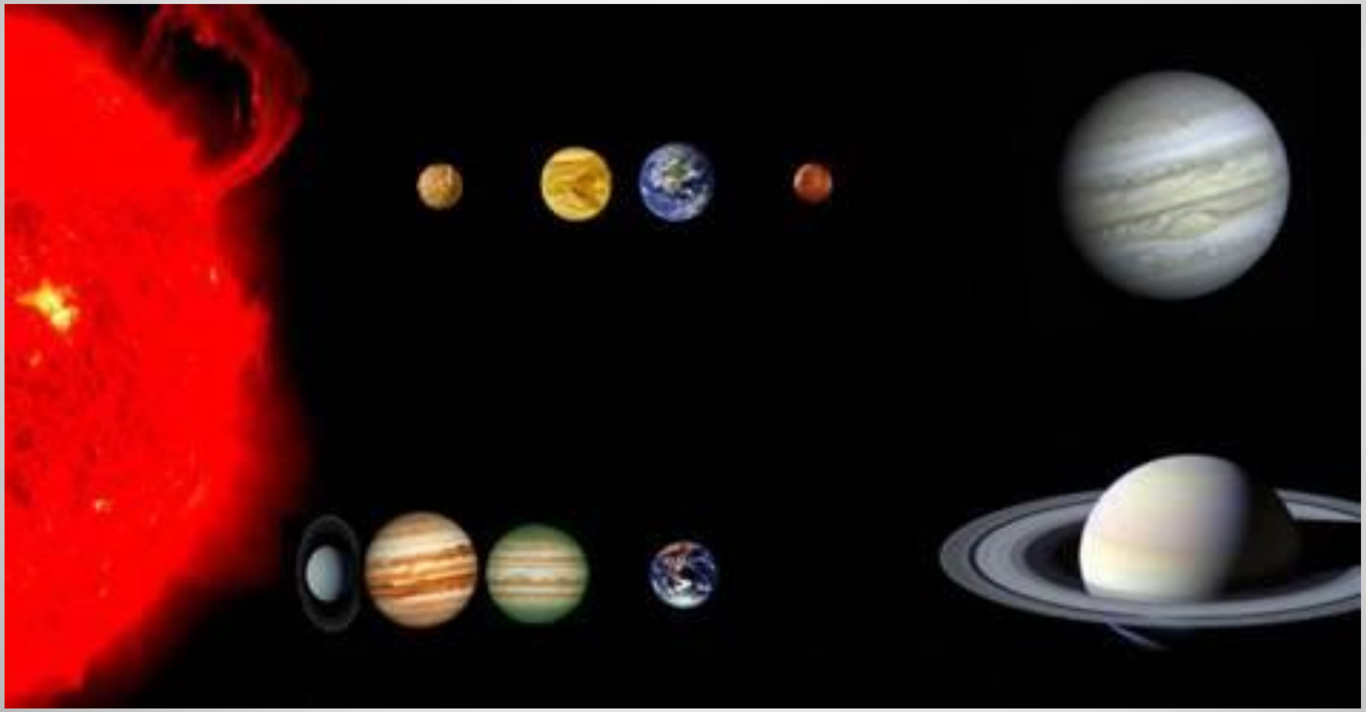
Exoplanet Systems

- As of what has been released to the ________ , astronomers haven't found a system that looks ________ like our own
- The nearest match so far is the system of planets orbiting the star *55* ________
  - This sun-like star has five planets orbiting within ________ AU of the star just like ours
  - All of the planets are massive (10x Earth)
  - 3 of the planets orbit closer to the star than ________ does from the Sun

Other Planetary Systems

Exoplanet Systems

- *55 Cancri*



Other Planetary Systems

Exoplanet Systems

- *55 Cancri* and its set up really _________ our understanding of how the solar system set itself up
  - having _________ gas planets so close to the star
  - According to solar nebula, they should've formed much _________ back off of the star where the temperatures are much lower
  - Astronomers are working on understanding what's different in _________ like that one that make this scenario possible in its solar system and not ours

Other Planetary Systems

Exoplanet Systems

- It is thought that planets in other systems might have the ability to "__________ " within the system
- Others are known to have __________ orbits rather than circular ones which can damage or effect the orbits of smaller planets in that same __________
  - This can either eject them out or cause them to crash into the star

The __________ continues….