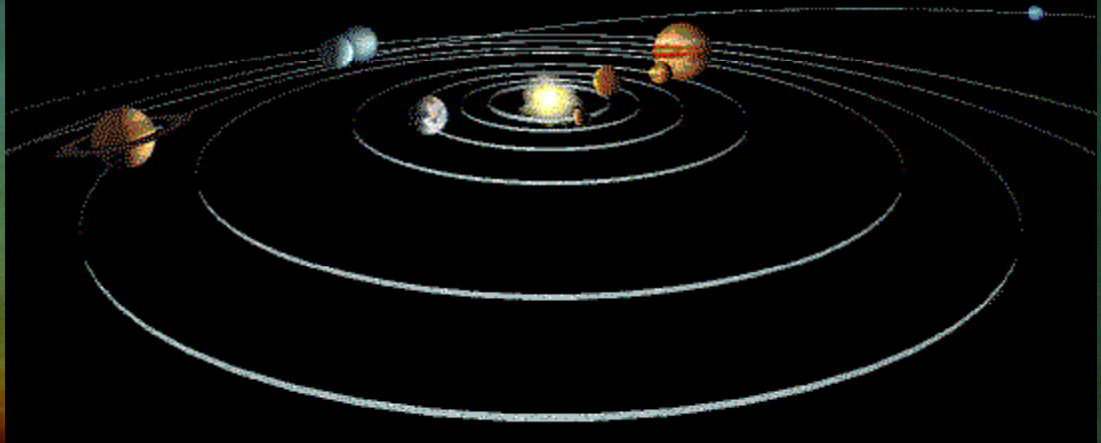


# Planet Formation

1. What is the “Nebular Theory”
2. Why do interstellar clouds collapse?
3. What might prevent the initial collapse?
4. Why does a disk form?
5. What was the composition of the initial cloud?
6. How do solids form?
7. Why do different solids form in different regions?
8. Why are the planets differentiated?
9. Why is there rubble?

# Solar System





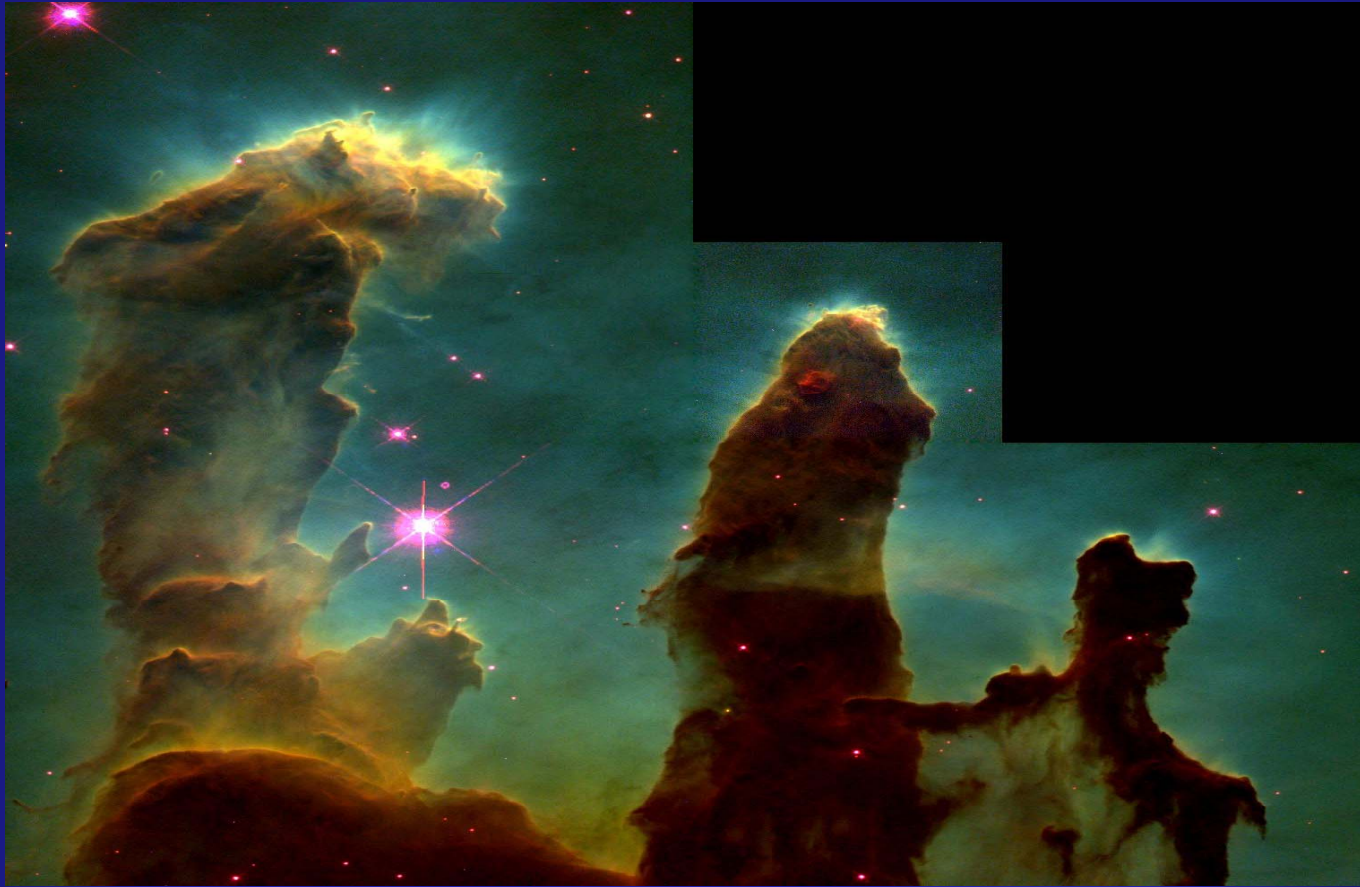
# Planetary Formation



**A Formation Scenario must answer**

1. Origins of the orderly motion.
2. Differentiation of material
3. Rubble
4. Exceptions

# The Nebular Theory

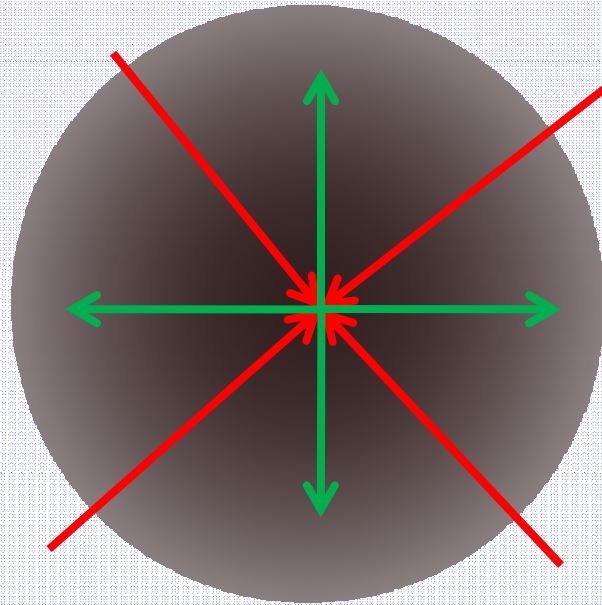


The solar system formed from the collapse of a giant cloud of gas



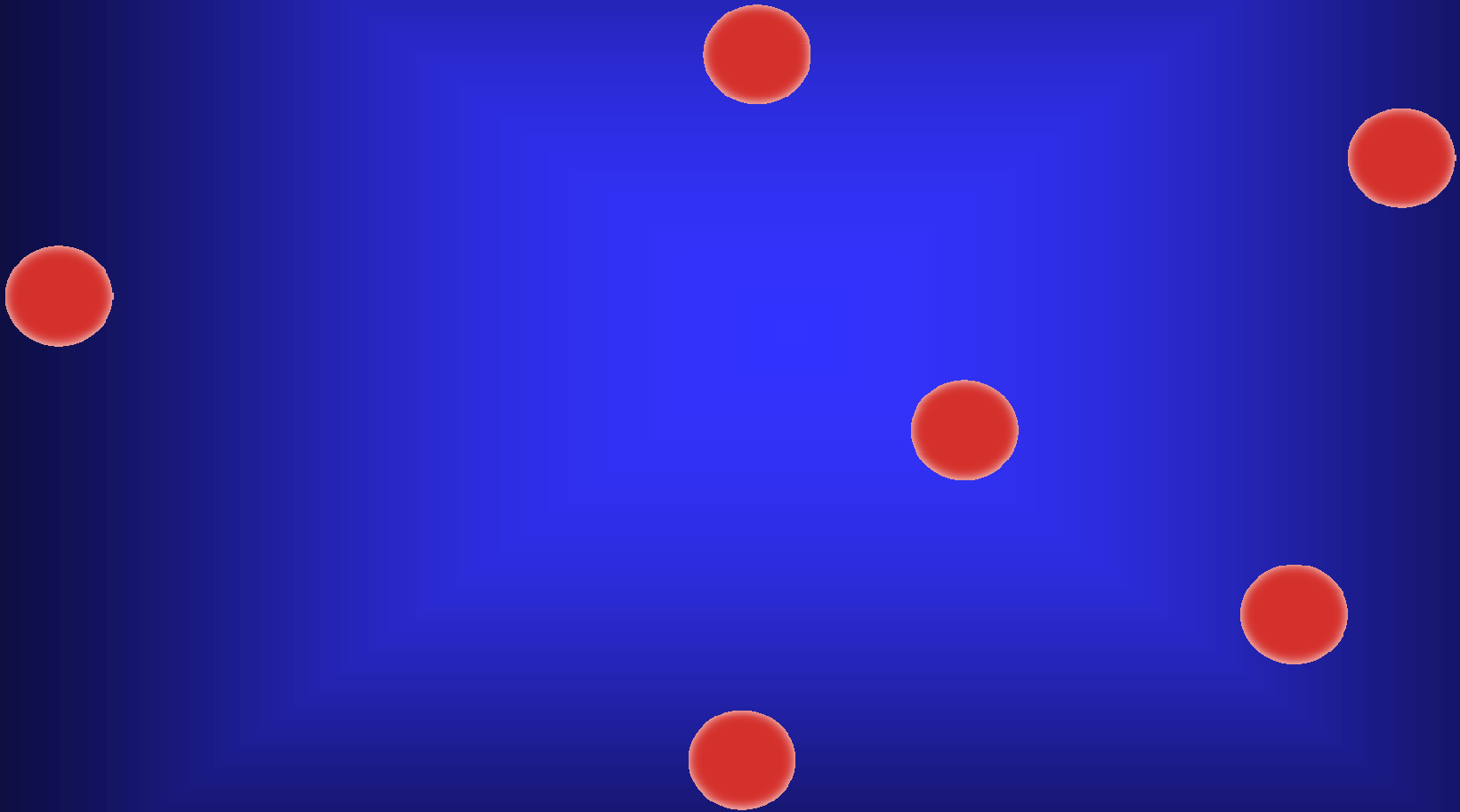
# Collapse

**Gravity**

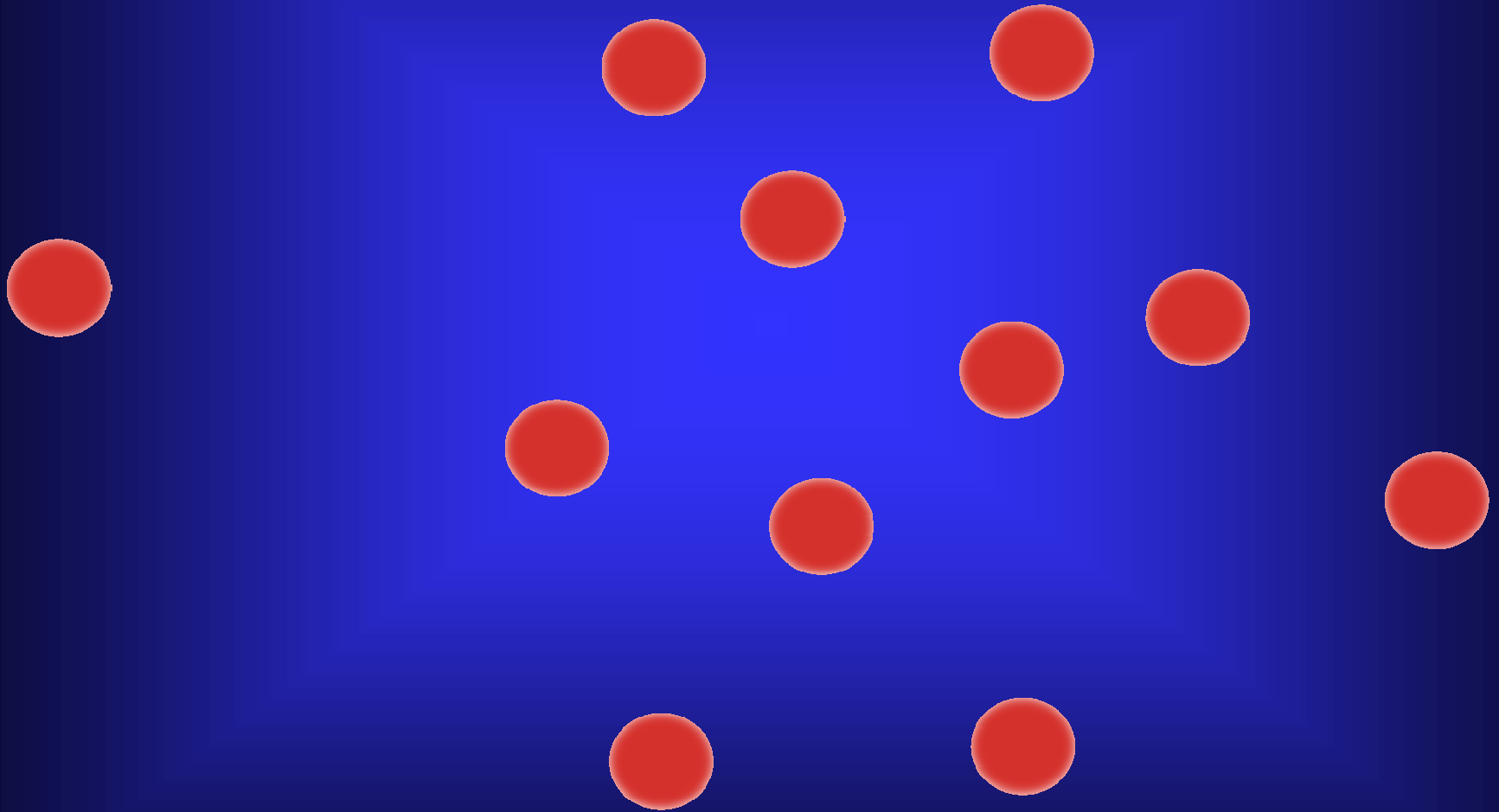


**Pressure**

# Collisions



# Collisions

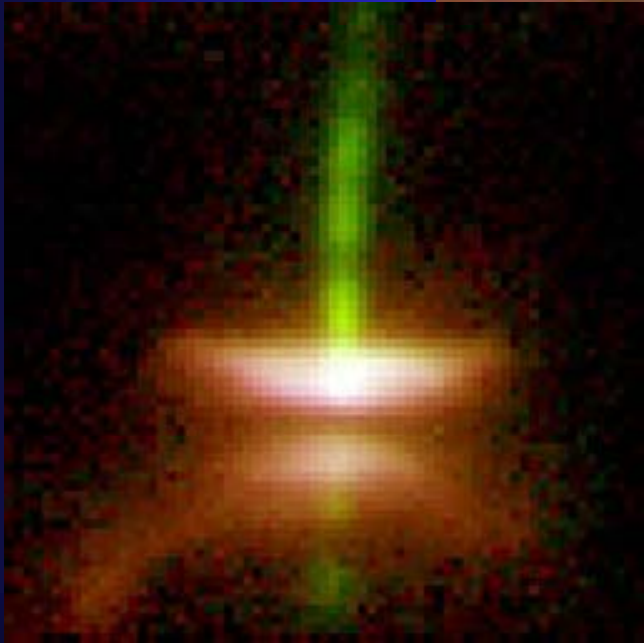
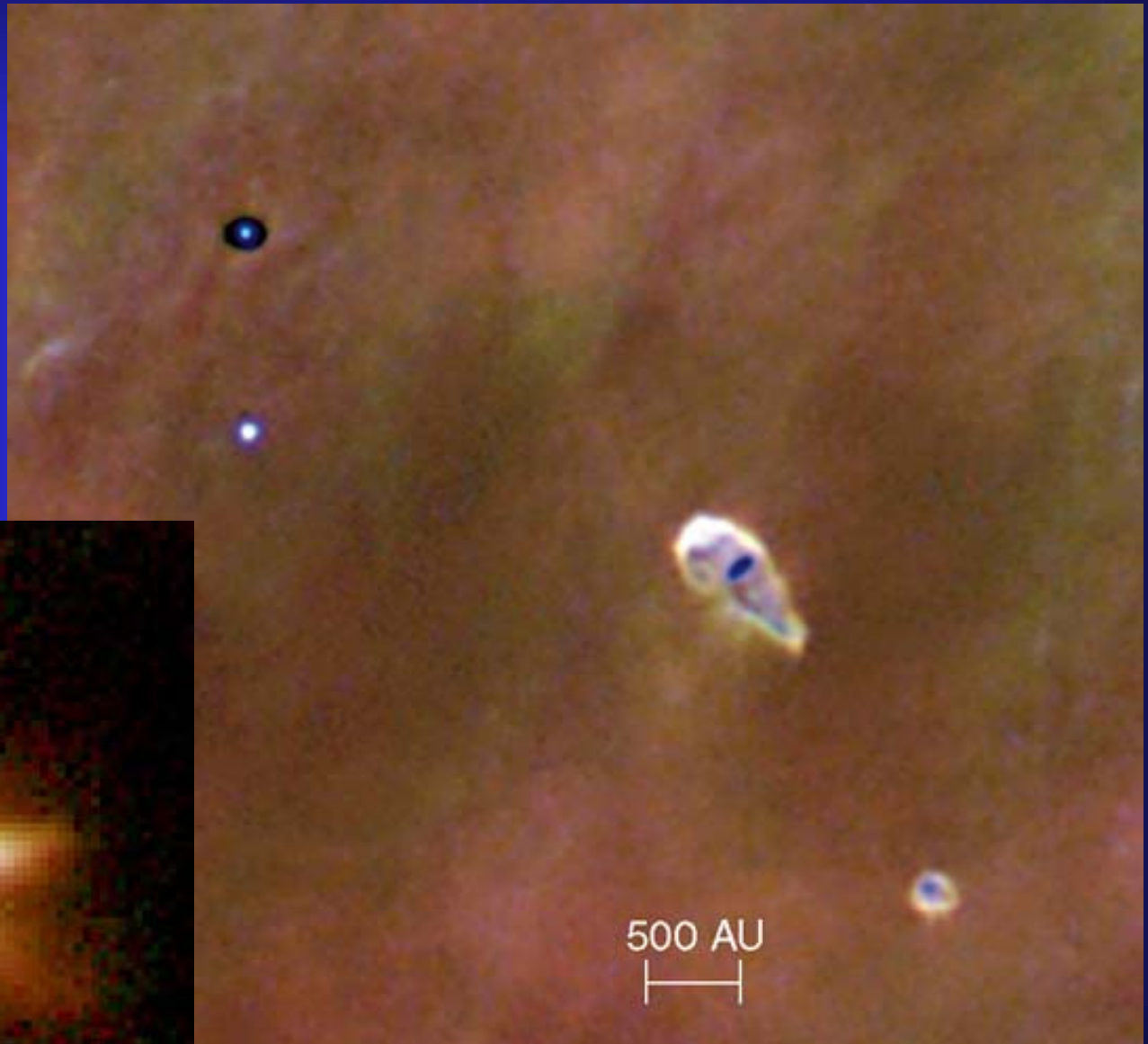


# Spinning into a disk





# Disks In Space!



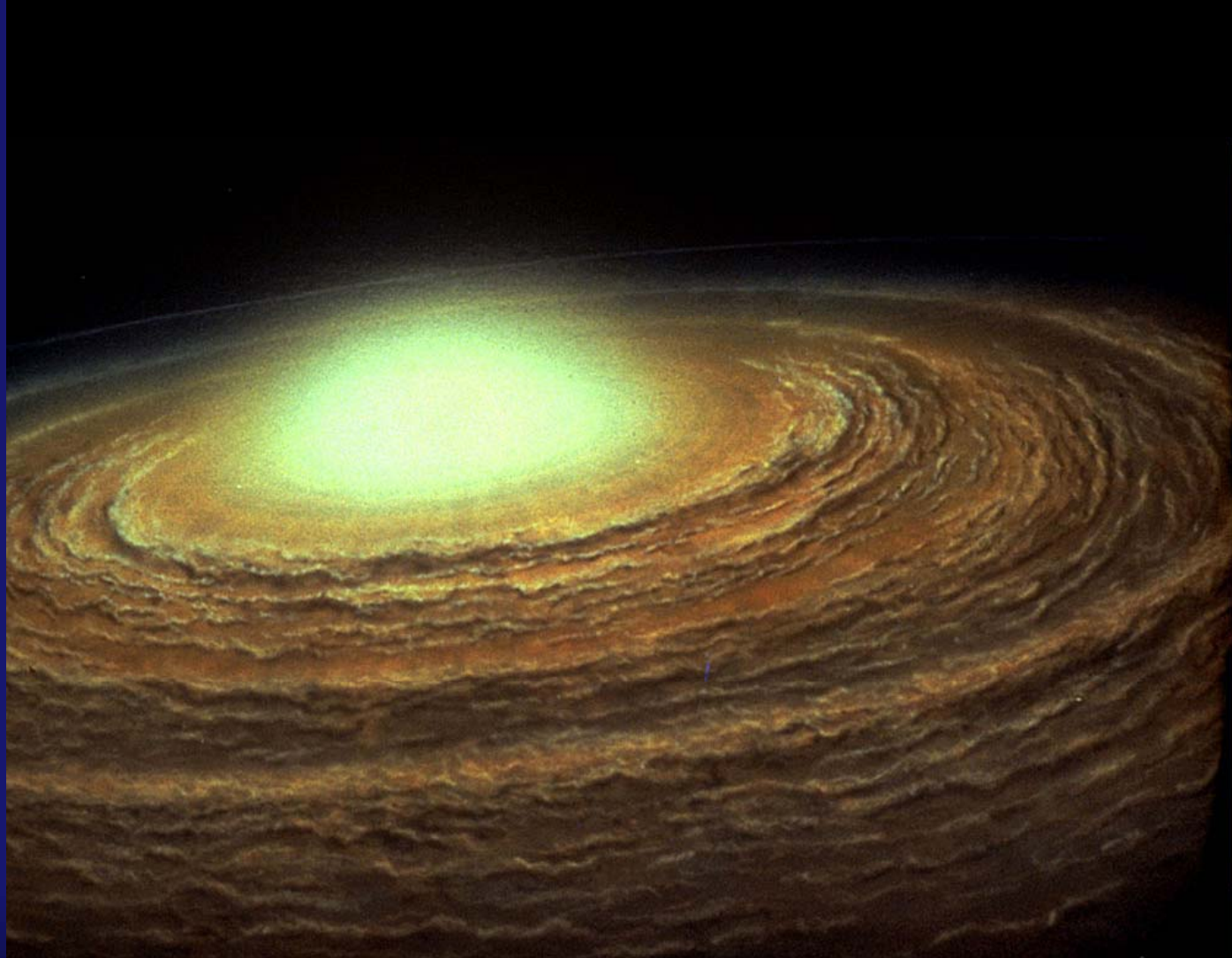
# ABCD

The interstellar cloud initially collapsed because

- A. its gravity was very weak.
- B. collisions between particles squeezed it down.
- C. gravity was stronger than the internal pressure.
- D. The cloud was extremely hot.



# The Dusty Disk



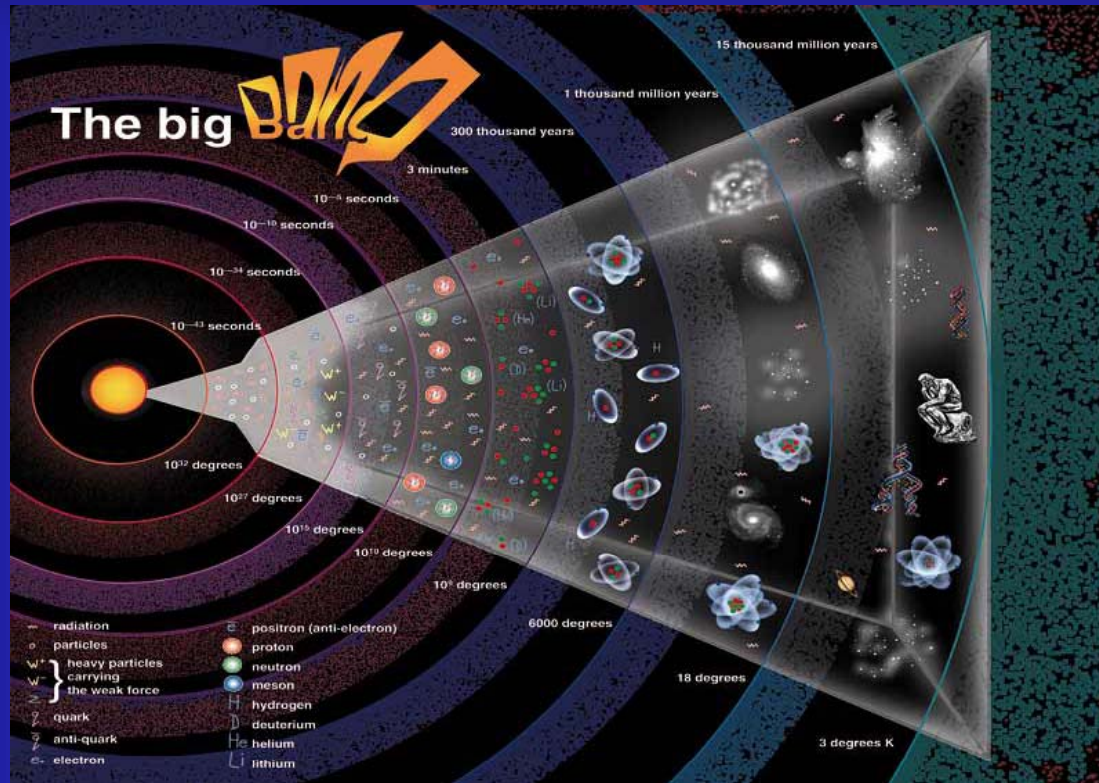
# Orderly Motion

## **The Nebular Theory explains why**

1. All orbits are in the same plane
2. Everything orbits in the same direction around the sun
3. MOST things spin in the same direction
4. All of the spin axis are approximately aligned



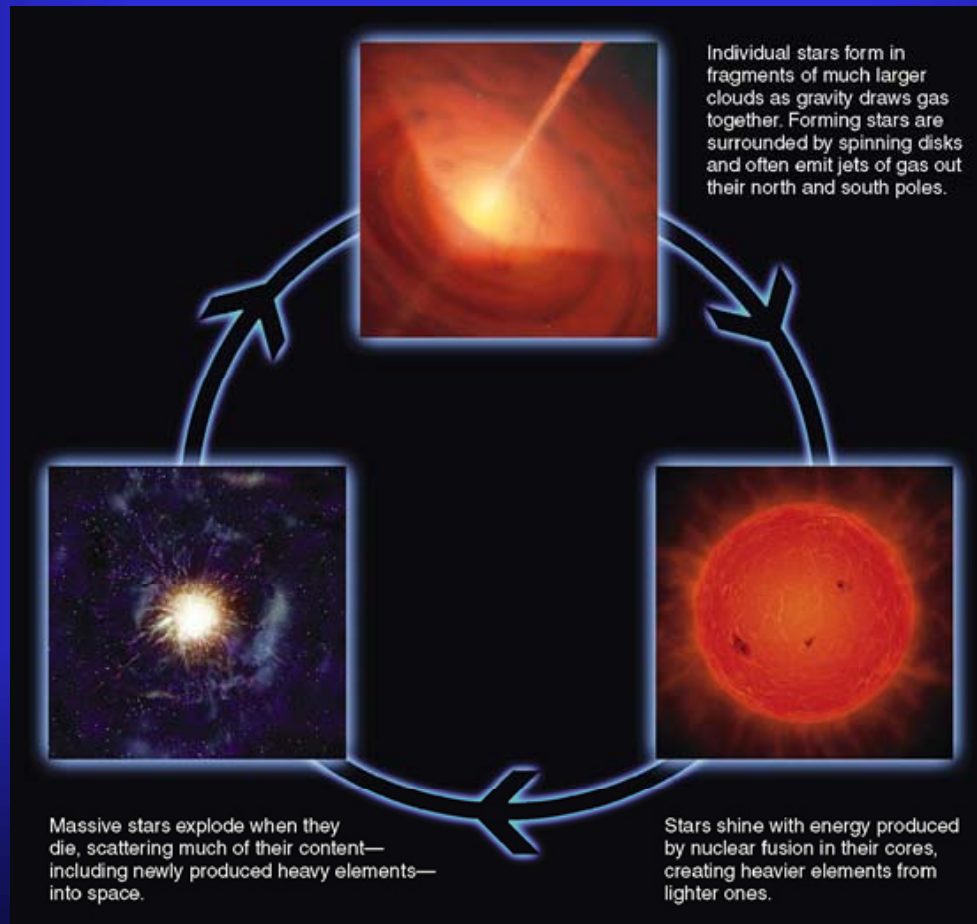
# History of Matter I



Only H and He in the BB  
No heavier elements

# History of Matter II

Heavier elements are made by stars.





# Star Formation

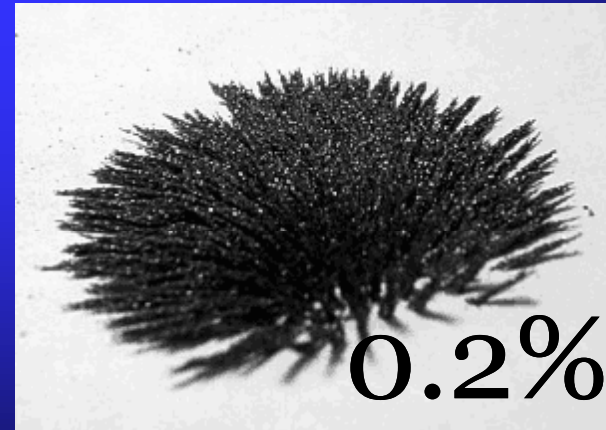
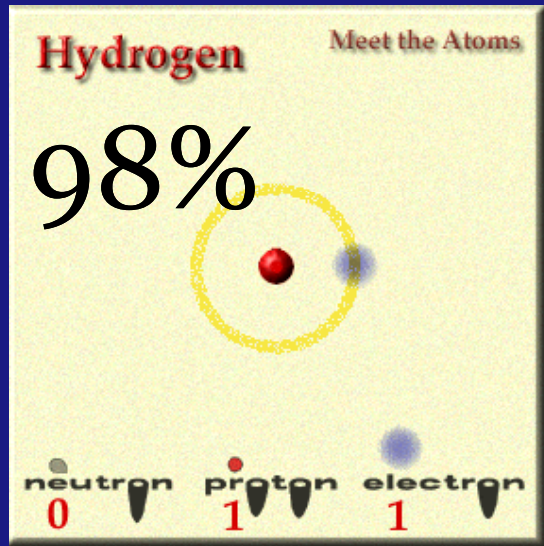


# Planet Formation

1. What is the “Nebular Theory”
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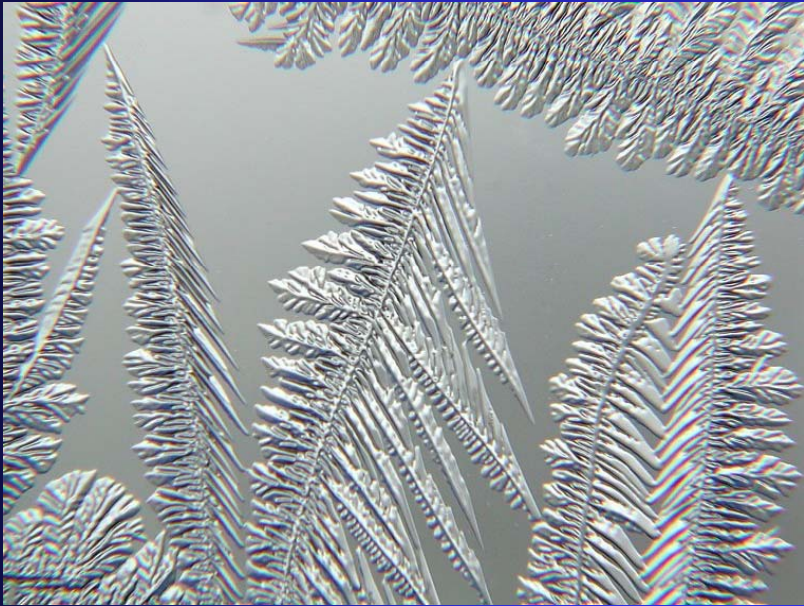


# Composition



Assume that the disk was **WELL MIXED**

# Condensation



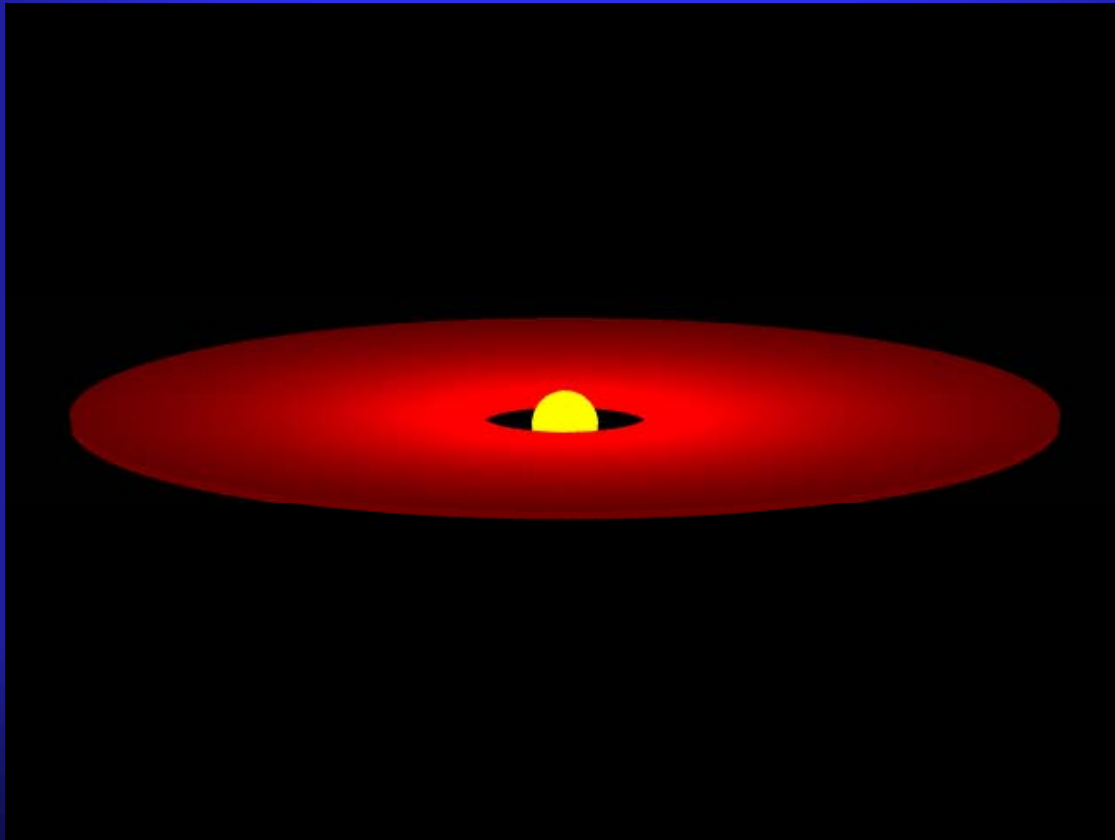
LIGHT compounds  
require LOW  
temperatures.



HEAVY compounds can  
condense at HIGH  
temperatures

# Disk Temperatures

The disk temperature decreases  
with radius





Only rocky planets formed in the inner solar system because:

- A. There are no rocks in the outer solar system.
- B. Ice couldn't condense in the inner solar system.
- C. Gravity sucked the heavy rocks inward.
- D. The heavy planets (Jupiter etc) were flung outward.



# The Frost Line



# Building Terrestrial Planets



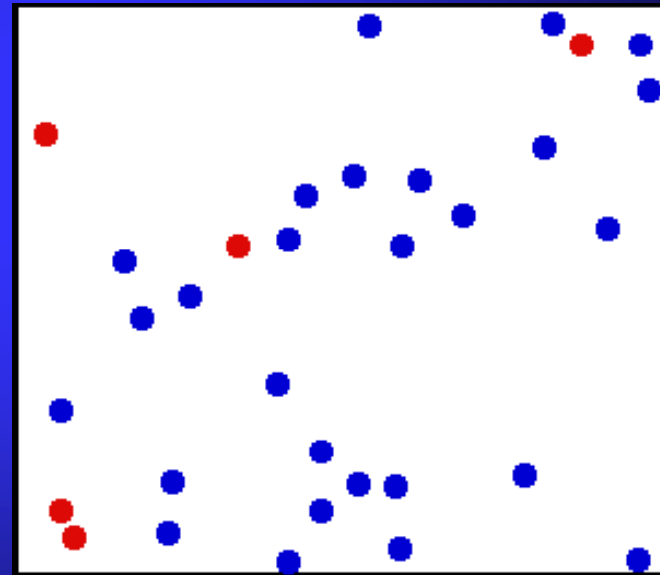
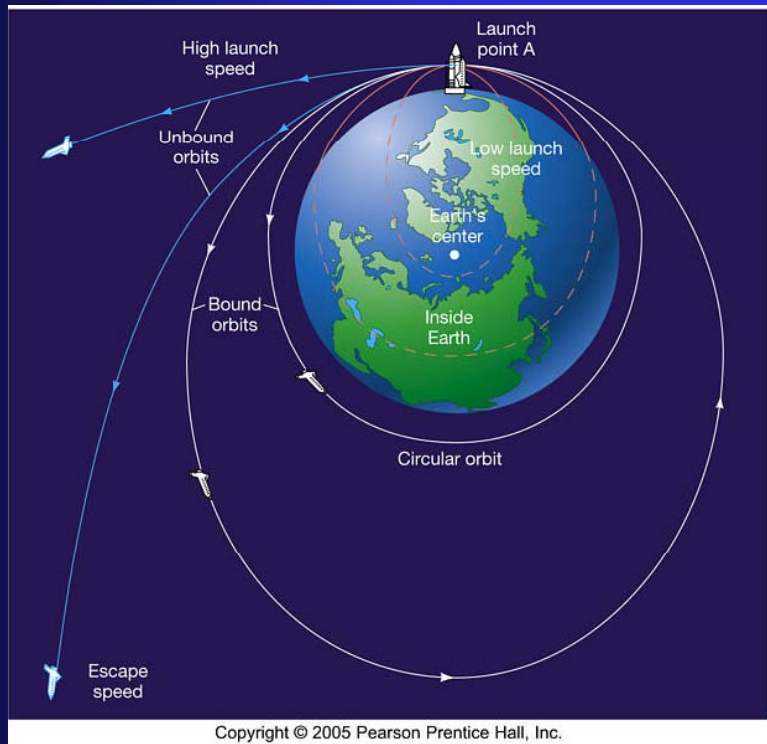
The rocks bash together and stick to form planets

The terrestrial planets have no hydrogen atmosphere because

- A. Hydrogen is light and terrestrial planets are warm.
- B. The Sun blows the hydrogen away.
- C. There was very little hydrogen in the disk when the Earth formed.
- D. All of the hydrogen got fused inside the Sun.

# Building Terrestrial Planets

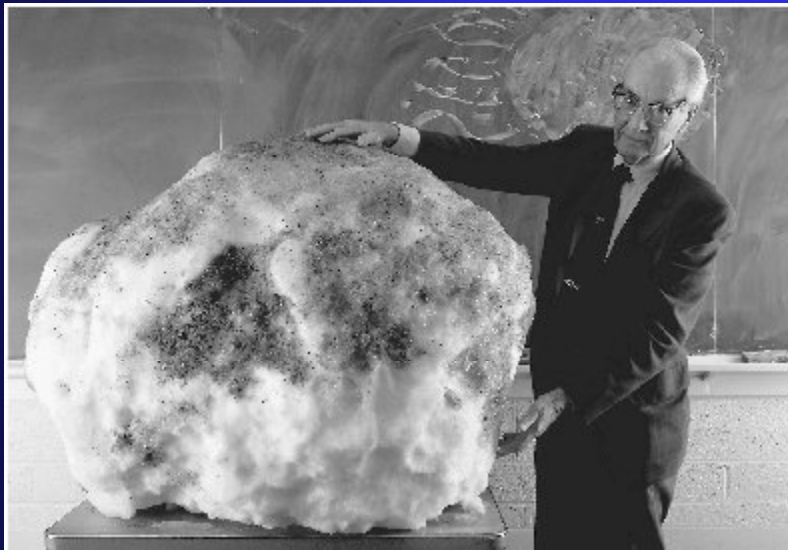
## Where's the hydrogen?



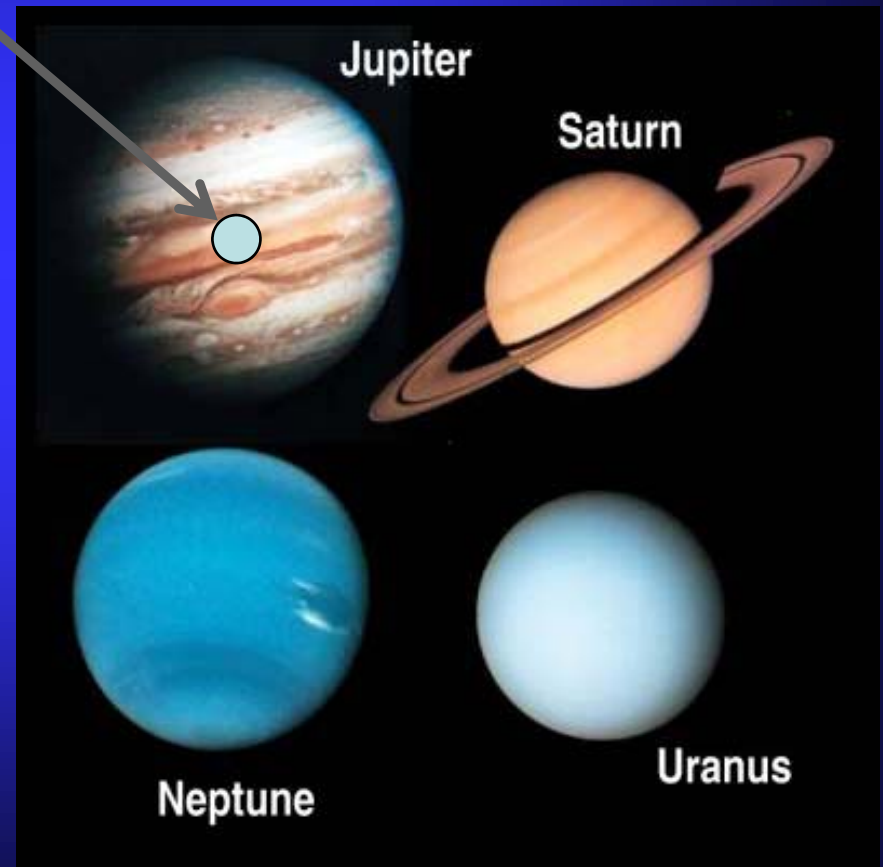


# Building Jovian Planets

A BIIIG dirty snowball



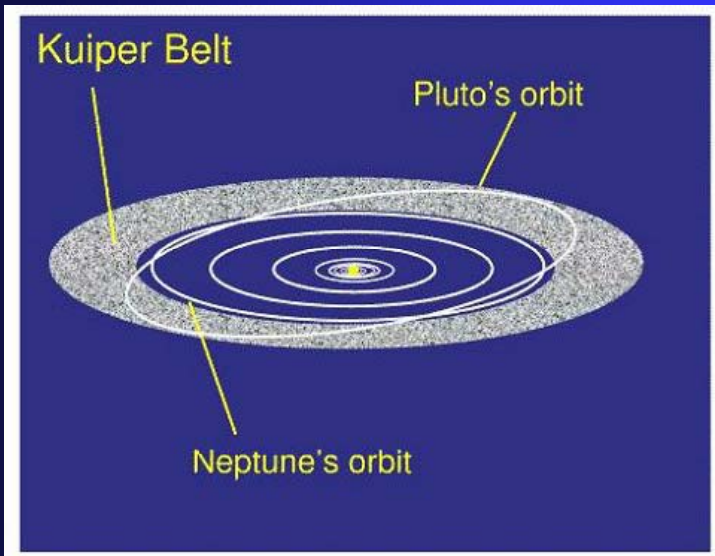
A dirty snowball



# Leftover Rocks and Ice



The asteroid belt is likely a failed terrestrial planet



The Kuiper belt is leftover debris from jovian planet formation



The Jovian planets have HUGE hydrogen atmosphere because

- A. they have massive cores and are cold
- B. they have massive cores and are warm
- C. they have no cores and are cold
- D. they have no cores and are warm



Mercury's atmosphere is likely extremely thin because

- A. of its large mass
- B. of its slow rotation
- C. it's very close to the sun
- D. of large impacts in the past

# Solar System Age



Radiometric  
dating of rocks

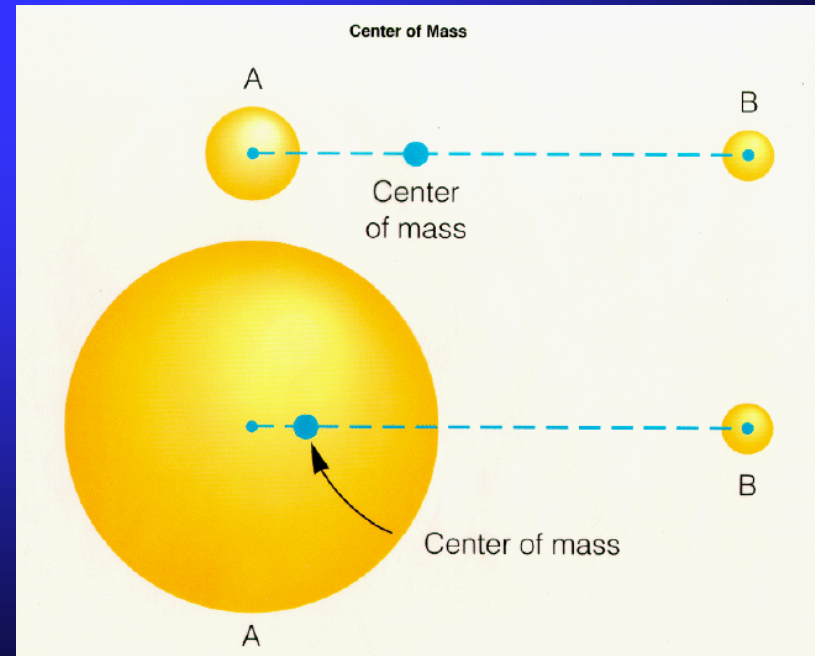
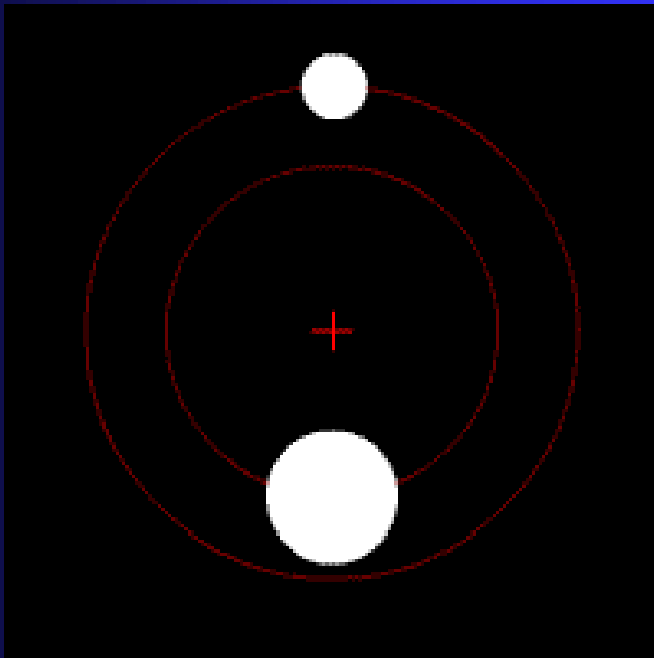


Stellar evolution  
theory

about 4.5 billion years old

# Orbits... again

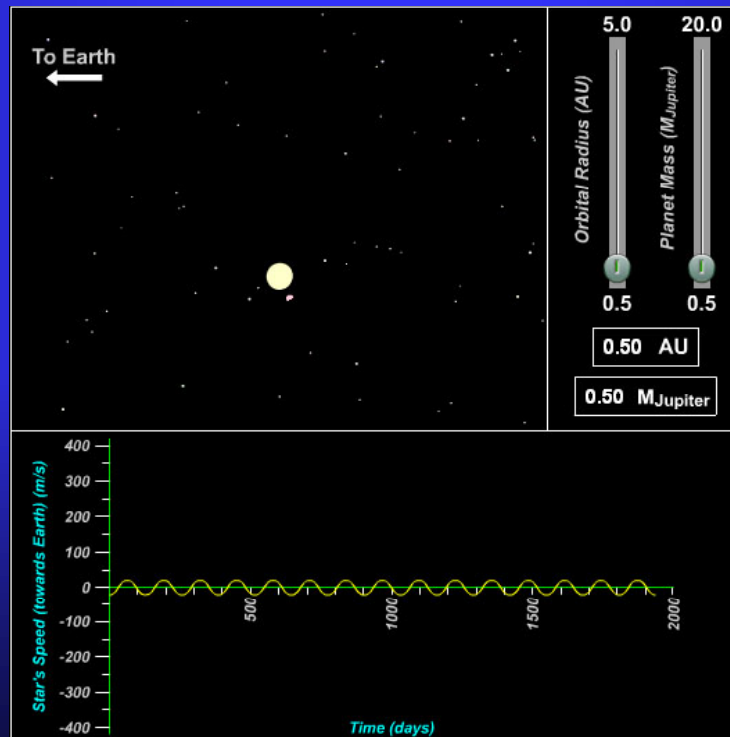
Objects orbit around their  
centers of mass





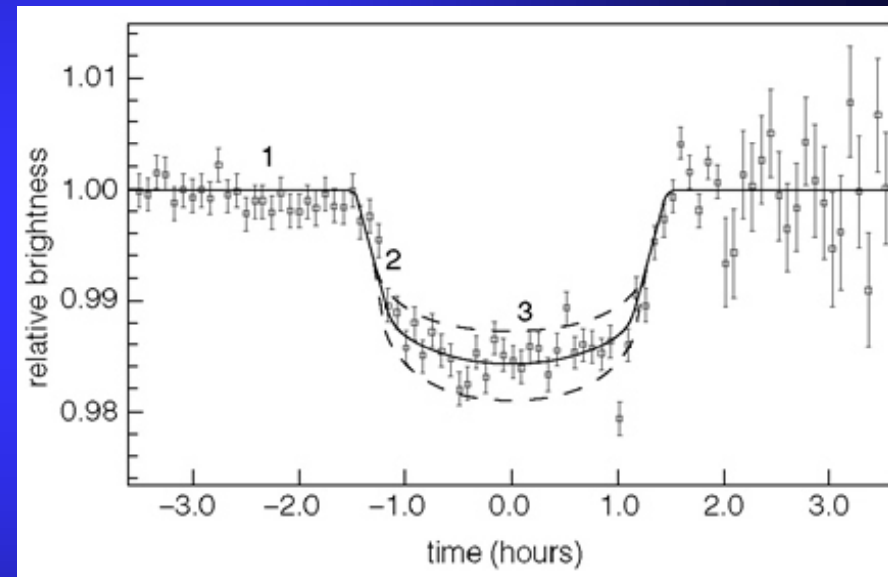
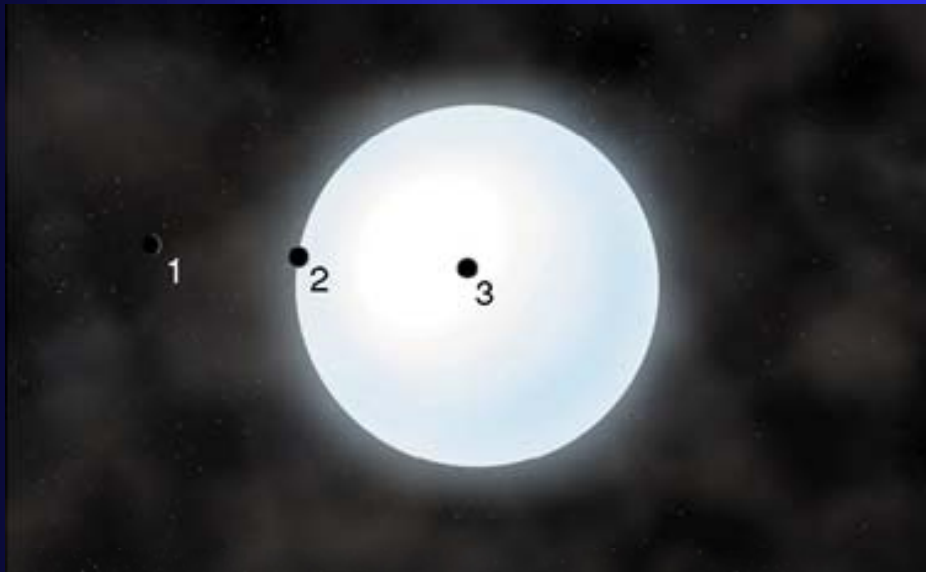
# Extra Solar Planets I

Extra Solar means around a star that is not the Sun



# Extra Solar Planets II

Transits can be detected by the light curve



The transiting planet blocks some of the starlight