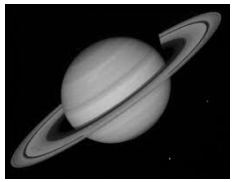


ASTR 105
The Solar System

Today: Group Lab at the end of class
Next THURSDAY 03/10: First Group Project

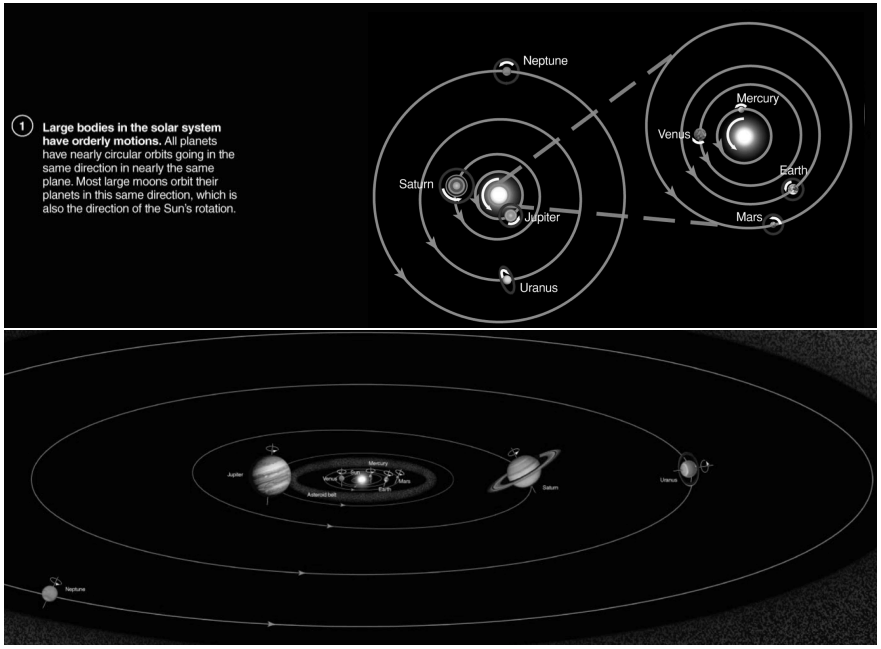
Patterns in the Solar System

1. Orderly motions
2. Two kinds of planets
3. Two kinds of small bodies
4. Exceptions to the rules

Patterns in the Solar System

Orderly Motions

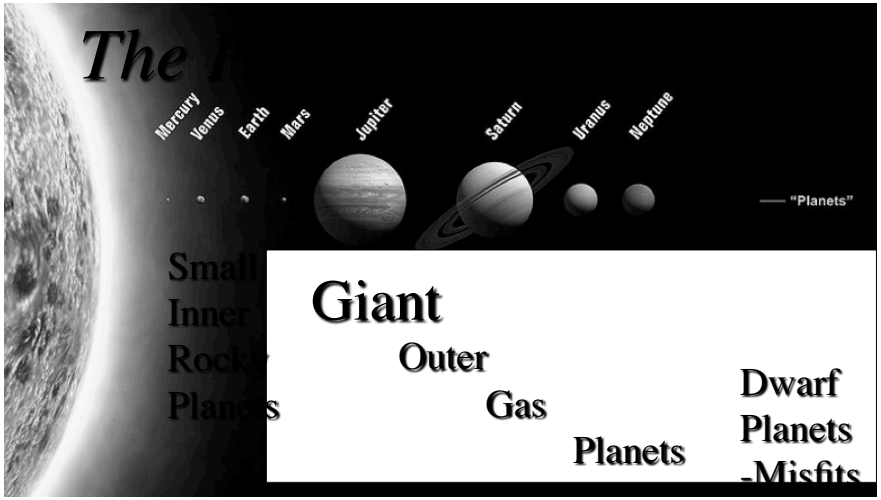
- Almost every body orbits & spins in the same direction.
  - Counterclockwise from above
- Planetary orbits nearly circular, lie in nearly the same plane.
  - Large moons tend to exhibit the same properties.



Patterns in the Solar System

Two Types of Planets

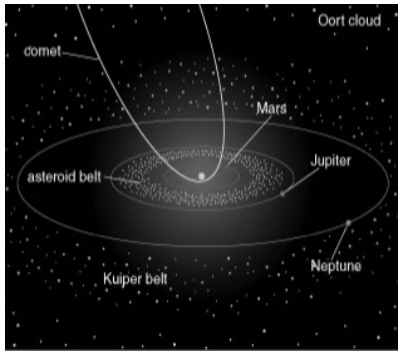
Terrestrial Planets	Jovian Planets
• Smaller size and mass	• Larger size and mass
• Mostly rock and metal	• Mostly H, He, and H-compounds
• High density	• Low density
• Solid surface	• No solid surface
• Few or no moons, no rings	• Rings and many moons
• Closer to the Sun, closer together	• Farther from the Sun, farther apart



Patterns in the Solar System

Two Types of Small Bodies

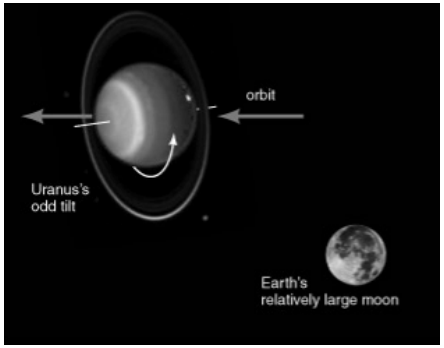
- Rocky
  - Asteroids
- Ice and rock
  - Comets
    - Kuiper belt objects
    - Oort cloud comets



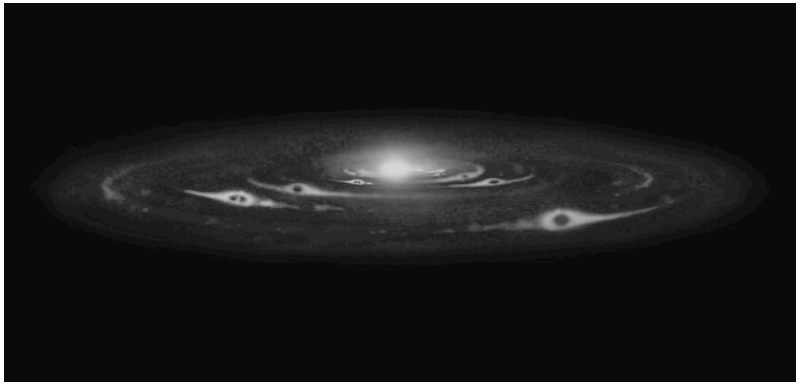
Patterns in the Solar System

Exceptions to the rules

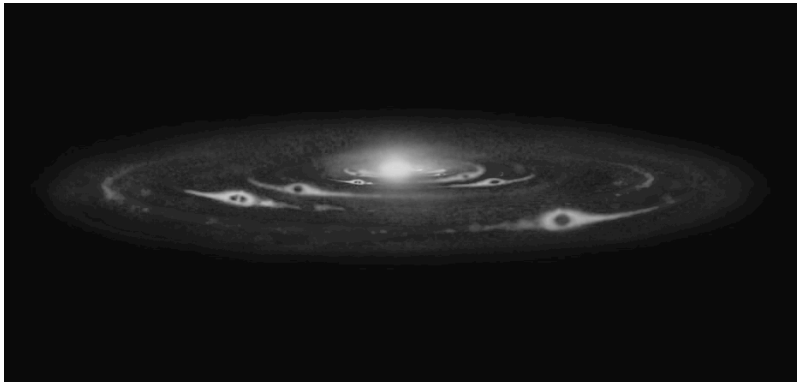
- Rotations
  - Venus
    - Backwards
  - Uranus
    - On its side
- Orbits
  - Triton
    - Backwards
- Moons
  - Earth's Moon
    - Big (compared to Earth)
  - Most small moons
    - Screwy shapes & orbits

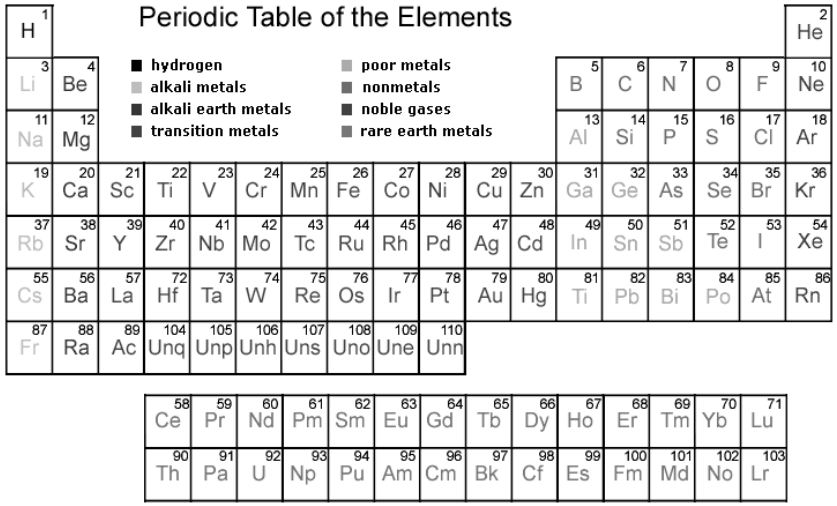


Next:
Formation of the Solar System

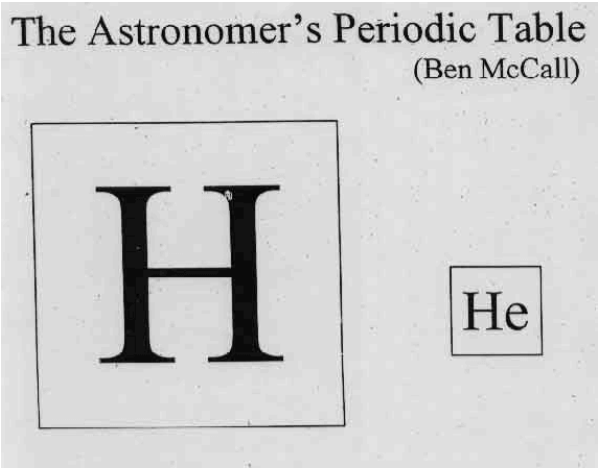


Where did the elements in the solar nebula come from?



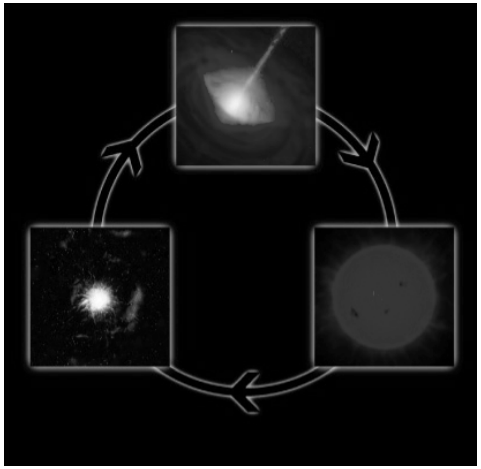


Right after the Big Bang



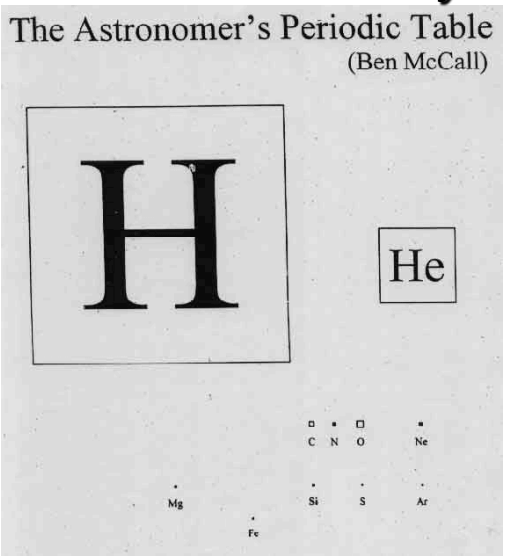
- Mostly **Hydrogen (75%)**
- Some **Helium (25%)**
- **Virtually nothing else**

Galactic Recycling



- H & He
  - created in the Big Bang
- Heavier elements
  - made in stars and then recycled through interstellar space

Today



- Almost entirely Hydrogen (70%)
- Some Helium (28%)
- Tiny amount of everything else (2%)

Clicker Question

What would the "Astronomer's Periodic Table" look like if we looked at the universe in 13 billion years?

A. It would look exactly the same
B. The H would be a little smaller but not much, other elements a little bigger
C. The H and He would be pretty much gone, all converted to heavier elements
D. All the elements would be the same size (I.e. the same amount of everything)

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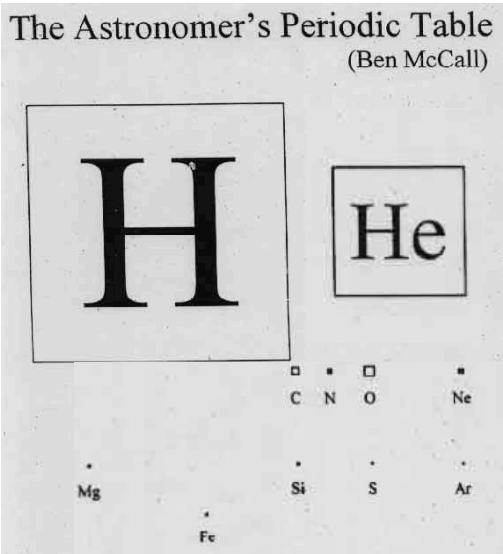
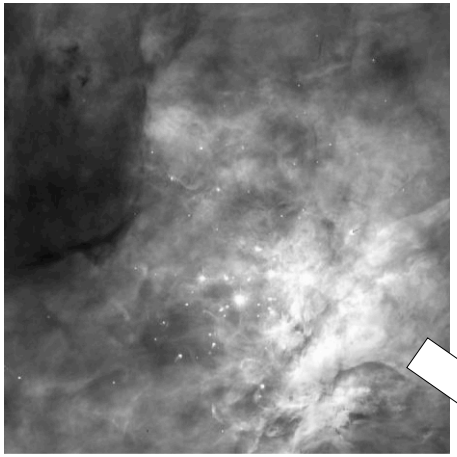
13 Billion Years From Today

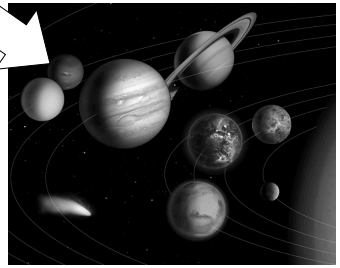


- Still mostly Hydrogen (65%)
- A bit more Helium (31%)
- A little more of everything else (4%)



NEBULAR FORMATION
Theory
for the Solar System

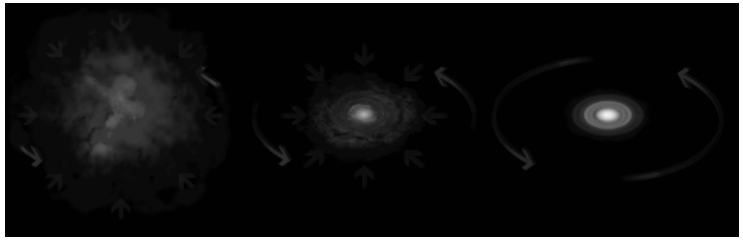
How does a solar system form from a cloud of gas?



Four Challenges for a Solar System Formation Theory

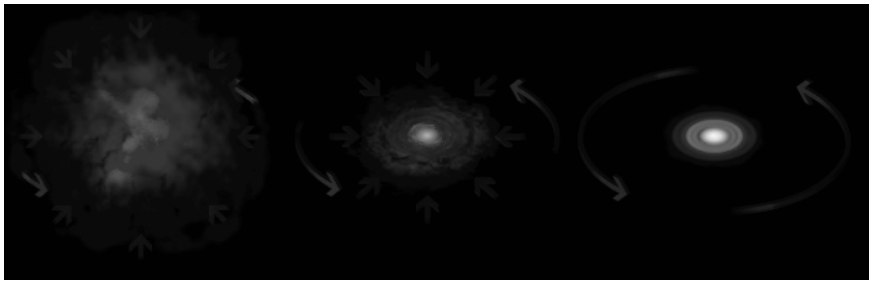
1. Orderly motions
2. Two kinds of planets
3. Two kinds of small bodies
4. Exceptions to the rules

Collapse of the Solar Nebula

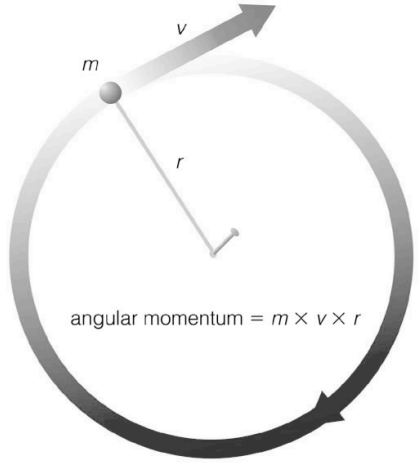


- As the solar nebula collapses it:
  - Spins faster
  - Heats up
  - Flattens out into a disk

Collapse of the Solar Nebula



Why does it spin faster?



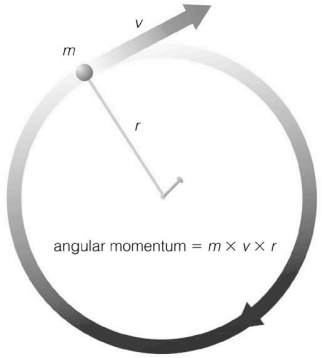
Conservation of Angular Momentum

M x V x R = Constant

Clicker Question

If angular momentum (m×v×r) *is conserved (stays constant) what happens if r goes down (no change in m)?*

A. v stays the same
B. v goes down
C. v goes up



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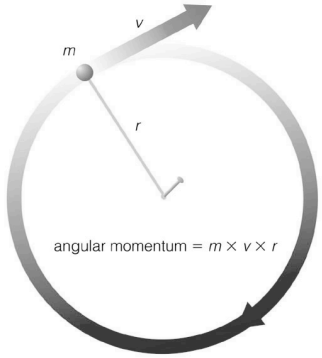

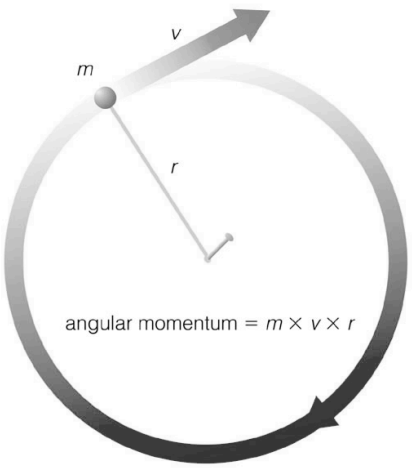

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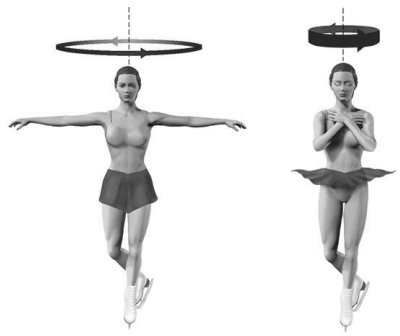
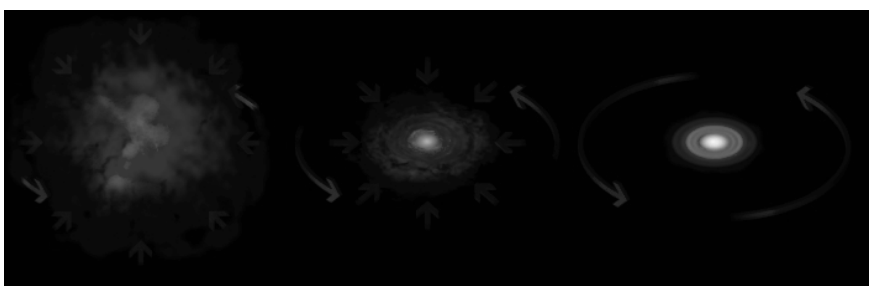


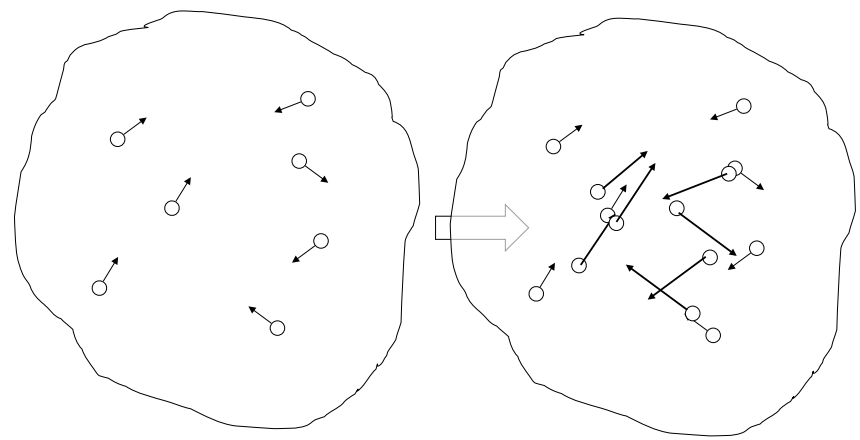
Spinning Demos

https://www.youtube.com/watch?v=UZlW1a63KZs

Collapse of the Solar Nebula

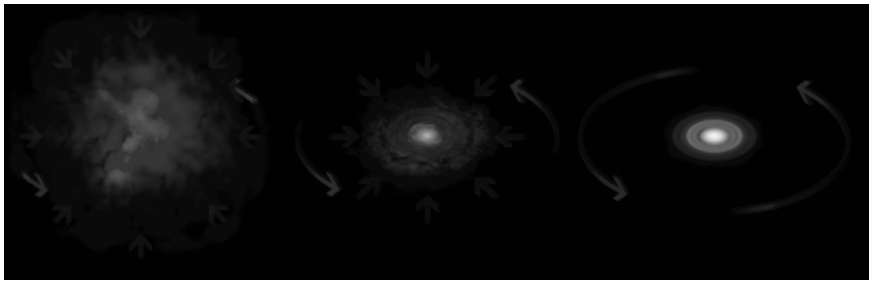


Why does it heat up?



Gravitational Energy ⇒ Kinetic Energy
Kinetic Energy = Thermal Energy

Collapse of the Solar Nebula



Why does it flatten into a disk?

Incorrect Reasons

Gravity is "pulling the material into a disk"

- Gravity is pulling everything in (spherically, not into a flat disk)

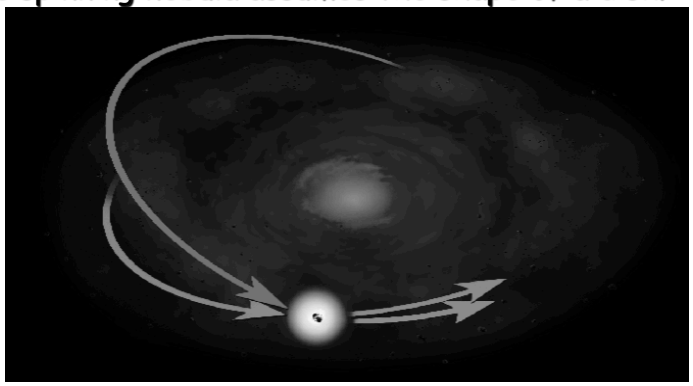
OR

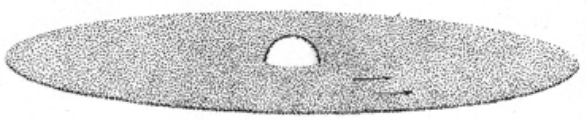
The disk is being "flung out into a disk"

- Individual gas particles are in simple orbits (orbits don't get flung out)

Flattening of the Solar Nebula

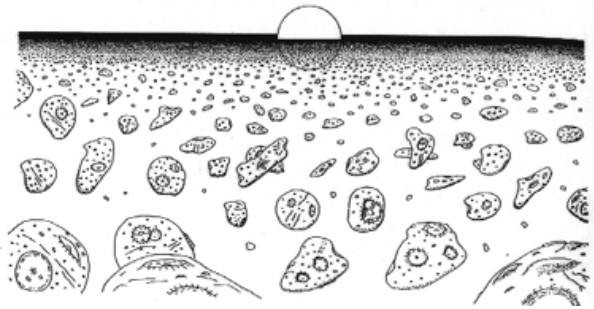
- As the nebula collapses, clumps of gas collide & merge.
- Their random velocities average out into the nebula's direction of rotation.
- The spinning nebula assumes the shape of a disk.





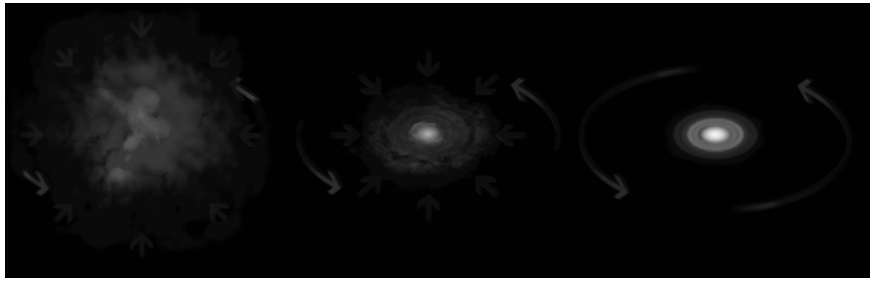
Extreme Conformism!

Go with the flow or crash to oblivion



Solar Nebula:

- SPINNING
  - Conservation of angular momentum
- HOT
  - Collapse ⇒ compression
- DISK
  - Collisions force common motions



LAB

a) The orbital period of the Moon is 29.5 days, and its distance from Earth is 238,900 miles. What is the mass of the Earth?

b) The New Horizon spacecraft will take 9 years to travel to Pluto ($D=7.5\times10^9$ km). What is its average speed?

c) Uranus's orbit lasts 84 years. If you live at its South pole, for roughly how long would you see continuous day light?

d) A new planet is discovered, orbiting a star of mass $M=2\times10^{30}$ kg in 5.7 years. At what distance from the star is the planet orbiting?

e) List at least 3 differences between Pluto and the other solar planets. What feature did astronomers agree upon as a way to differentiate a 'planet' from a 'dwarf planet'?