Age of the Solar System

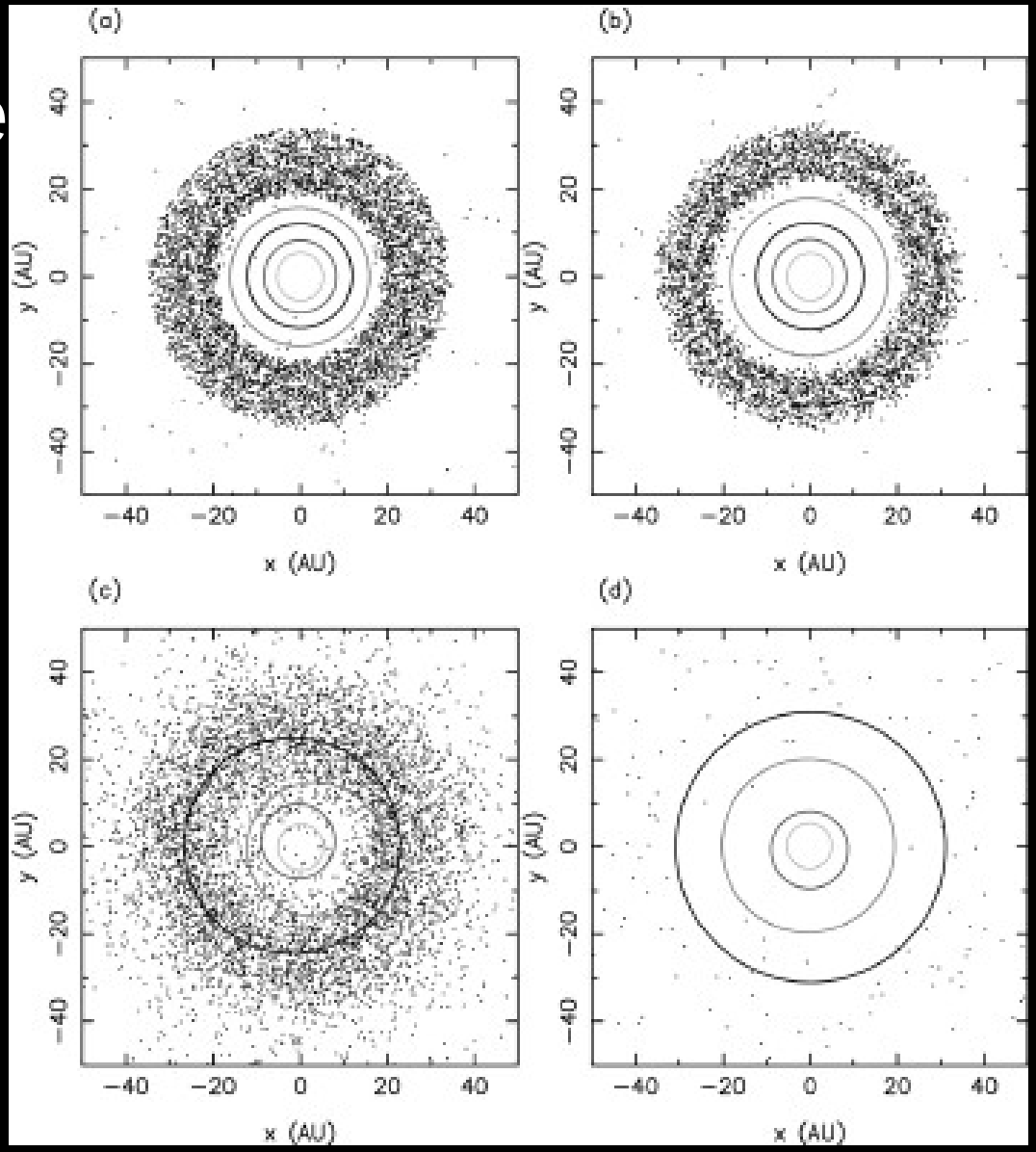
11/2/2009

Opening Discussion

- http://www.youtube.com/watch?v=44DlSj6bnn4&fea
- Have you seen anything interesting in the news?
- What did we talk about last class?

Nice Model

- This image sequence shows different stages in the evolution of the outer solar system as described by the Nice model.



Effects of Gas in the Protoplanetary Disk

- For most of the accretion process, there was a lot of gas in the disk. The mass of the gas was 50 times greater than the mass of the solids.
- This matters in many ways. Largely because the gas orbits more slowly than solid material. The gas is supported by pressure so it doesn't have to orbit as fast to resist gravity. As a result, all the particles feel a headwind.
- This drag impacts different sized particles differently. It can also cause particles to spiral inward.

Remnant Material

- Even after the planets were mostly formed, there was significant solid material left left in orbit.
- Some of this material is what we now see as comets and asteroids. The asteroid belt and Kuiper belt follow the general trends of motion we see in the planets. They also show the expected compositional differences.
- Remnant material that was close to the orbits of the planets would eventually have a close encounter or a collision with a planet. The close encounters with Jupiter and Saturn resulted in the Oort cloud. Impacts left craters on old surfaces.

Exceptions to the Rules

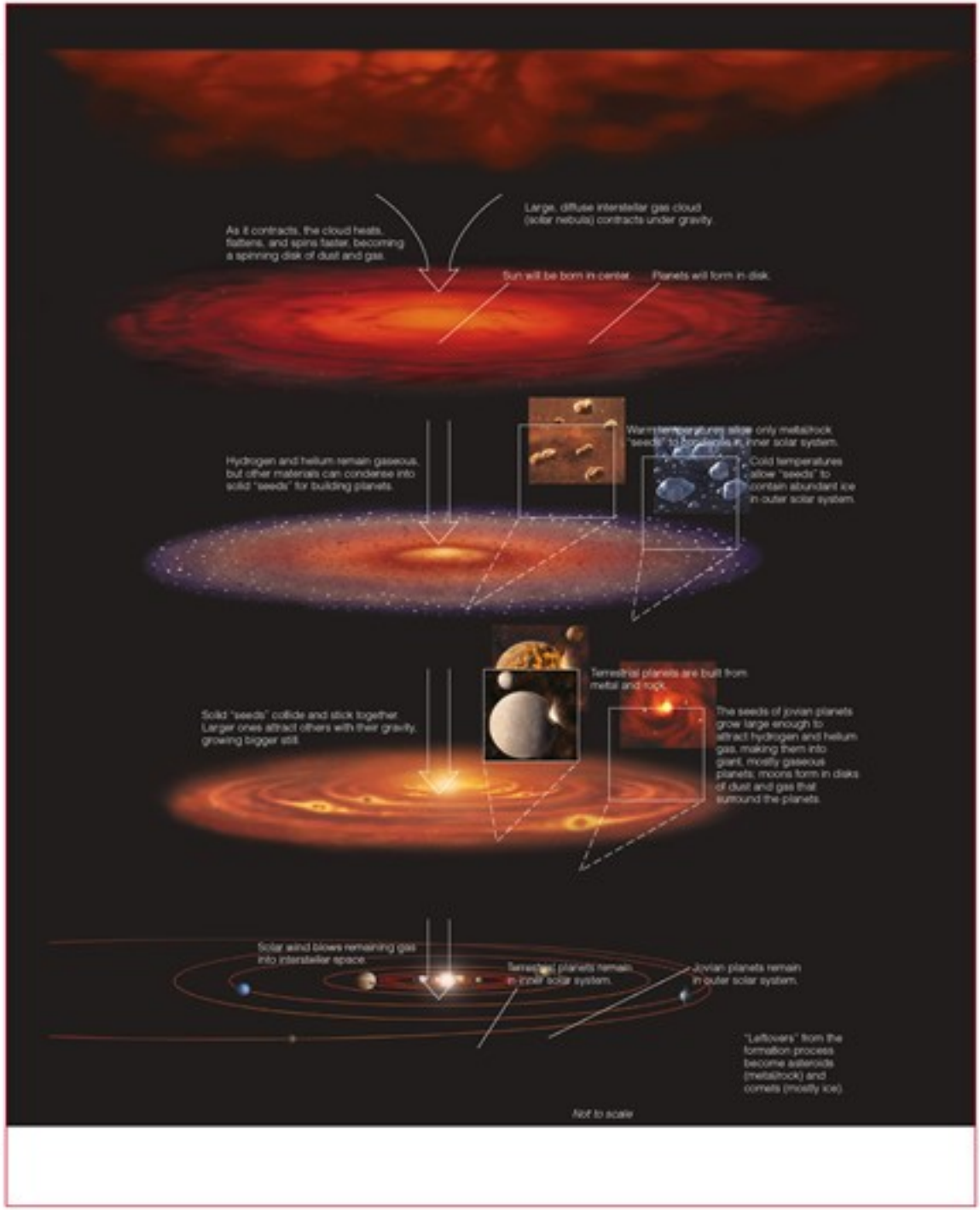
- Leftover material also provides us with explanations for many of the exceptions we see in our Solar System.
- Bodies that are captured into orbit can become retrograde moons. Capture is hard. A recent explanation involves bodies that are in binaries.
- Really big impacts have the ability do to make significant changes to the spin of a planet. This is likely what happened to Venus and Uranus. There were probably hit by a very large impactor in the late stages of formation.

Impact Formation of Moons

- The Earth's Moon is also likely the product of a giant impact.
- The Moon's composition is almost exactly like the mantle of the Earth, but depleted in volatiles. It's also nearly impossible to capture a body as big as the Moon.
- To explain this we believe that a body roughly the size of Mars hit the Earth.
- http://www.boulder.swri.edu/~robin/moonimpact/
- http://th.nao.ac.jp/~kokubo/moon/kit/movie.html

Summary Image

- Cloud
- Disk
- Condensation
- Accretion
- Heavy Bombardment
- Gas Removal



Radioactivity

- A common question for students in regards to science of things that happened a long time ago is, “How do we know when it happened?” For materials we can get hold of, the answer to this is that we do radioactive dating.
- Radioactive materials naturally change from one element to another. Measuring relative abundances of key elements allows us to get accurate measurements of the ages of samples.
- Some common examples are the potassium-40 decays to argon-40 and that uranium-238 decays to lead-206.

Calculating Ages and Half-life

- The key to determining ages is that decay is a probabilistic process, but for a given decay process, you can measure accurately how long it takes for a certain fraction of the material to decay.

$$\frac{current\ amount}{original\ amount} = \left(\frac{1}{2}\right)^{t/t_{half}}$$

- Potassium-40 has a half-life of 1.25 billion years. Uranium-238 has a half-life of about 4.5 billion years.

Minute Essay

- Do you have any questions about our current model of Solar System formation before we start talking about the terrestrial planets?