Ge 133 – Planetary Formation & Evolution
Final Examination

Out: 02 December 2011
Due: 09 December 2011
1 pm

This exam has a 4-hour limit and must be completed within a single block of time. It is totally closed book, notes, friends, neighbors, internet, dogs, cats, pygmy hedgehogs, etc. More seriously, the time limit is there mostly so that you are forced to finish, we don't think it should take you nearly this long.

The problems are worth 10 points each (so the individual parts of problem one are worth two points each, etc.).

Good luck!

1. **Order of Magnitude (Exo)Planetary Science**

To order of magnitude, give the following quantities, and *briefly, briefly, briefly* describe the evidence or theory used to constrain them:

- C/H ratio (by number) in the Interstellar Medium
- The mass of a Giant Molecular Cloud.
- The value of the α disk viscosity parameter required to explain disk lifetimes.
- Migration timescale of Jupiter if it opens a gap in the surrounding disk.
- Formation of FeNi cores in differentiated bodies & the final accumulation of terrestrial planets.

2. **Extrasolar Planets**

There are four "major" methods for detecting extrasolar planets – radial velocity surveys, transit surveys, direct imaging, and microlensing (astrometric surveys may ultimately yield a large number of detections, but we didn't cover this technique in the class very well, so we'll let you off the hook there). Compared to radial velocity (or astrometric surveys) alone, what further information about extrasolar planets can be extracted from transit measurements, especially if radial velocity data are also available? What wavelength regions are most important for extracting exoplanet physical properties?

3. **Disks and the Young Stars they Encircle**

Most cirucmstellar disks have never been imaged, and so we learn about them in ways akin to the parable of the blind men describing an elephant – from diverse lines of evidence. What do each of these features tell us about an individual circumstellar disk/young star in which they are seen: UV excess, lithium features in stellar photospheres, infrared excess (say, 1-30 μm), silicate emission features, millimeter-wave (excess) flux. How are disk evolution time scales obtained? Again, you can/should be brief!

4. **Planetesimal Growth**

What are the factors that can affect the velocity evolution of a planetesimal swarm and thus the formation of planetary embryos? Explain whether each effect increases or decreases the velocities/velocity dispersion. What effect dominates?

5. **The Core-Accretion Picture**

In the core-accretion model of Jovian planet formation, what are the major phases in the transformation of sub-micron sized dust grains into a full fledged planet? Why in such a model do Jovian planets form in the outer regions of forming planetary systems?

6. **Planetary Migration?**

What is the evidence that migration occurred in at least some extra-solar planetary systems? What is the physical mechanism by which such migration might have occurred, and what determines the different migration rates of the so-called Type I & II scenarios?

7. **Gas dissipation**

Describe the different ways in which the gaseous component of the circumstellar disk dissipates. Where in the disk is each of these most important? For extra credit, are their tracers that could *realistically* be used to examine these processes (in the solar system or astronomically) with current instrumentation?

8. **Our Own Kuiper Belt**

Sketch the eccentricity-major axis distribution for detected Kuiper Belt Objects (KBOs). Explain how we think each of these major features came to be, starting from a planetesimal disk in which Neptune is embedded. Why is Sedna so different from all other known KBOs?

9. **Other Kuiper Belts?**

For a planet orbiting a central star, how many Lagrange points are there? Which of these have stable orbits near them? Why do we care about these Lagrange points in the analysis of the debris disks around young main-sequence stars? Be sure to include in your argument the lifetime of $\sim$micron-sized dust particles in such systems.

10. **Meteorites and the Young Solar Environment**

From what materials do chondritic meteorites take their name? What are CAIs? From what region(s) of the solar system are meteorites delivered to the Earth? What can we learn about the solar nebula from such materials, and what lines of evidence are there that suggest the Sun may have formed in a young stellar cluster as opposed to relative isolation? What time scales are inferred? Are there processes in the pre-solar nebula that can confuse these putative signatures?