

## **ASTR 5820: Origin and Evolution of Planetary Systems**

<http://jilawww.colorado.edu/~pja/ast5820/>

**TIME & PLACE:** Tuesday / Thursday 11:00 am – 12:15 pm, Duane D142

**INSTRUCTOR:** Phil Armitage ([pja@jilau1.colorado.edu](mailto:pja@jilau1.colorado.edu); office JILA A909; phone 2-7836). There are no official 'office hours' for this class, you're welcome to stop by at any time to discuss the class. I'm normally in the office most afternoons / early evenings (2-6pm). Call or email if you want to be *certain* that I'm in before climbing the JILA tower.

**AIMS:** The primary goal is to provide an introduction to the formation and early evolution of planetary systems, including our own Solar System as well as extrasolar planetary systems. Since this is a graduate class, the hope is that it will prepare you to critically read papers in the field and, potentially, start your own research. The course should also provide some experience in numerical and analytic methods that may be useful in other contexts, and general research skills (reading and reviewing papers, giving presentations etc).

### **OUTLINE:**

1. Introduction: The Solar System, detection and basic properties of extrasolar planetary systems.
2. Protoplanetary disks: origin within the larger star formation picture, structure of passive and active disks, evolution of disks as accretion flows, sources of angular momentum transport within disks.
3. Planet formation: evolution of dust, formation of planetesimals, coagulation equation and solutions, different regimes of planetary growth, velocity dispersion of planetesimals, giant planet formation via core accretion and gravitational instability.
4. Early evolution of planetary systems: migration of planets of different masses within a gas disk, orbital evolution due to planetesimal scattering in the Solar System, dynamics of multiple planet systems.

**TEXTBOOKS:** It is generally agreed that there is no good textbook available that covers the syllabus of this course. I will be making available draft Chapters of a book that I am writing to supplement the lectures – comments and corrections on those are of course extremely welcome! On the class website you will also find links to a write up of the lecture notes from a previous version of the class, together with links to a selection of the most useful review articles.

Two books that you might consider buying are "Planetary Sciences" by de Pater and Lissauer (an excellent introduction that includes much more extensive discussion on the surfaces and atmospheres of the planets in the Solar System),

and “Solar System Dynamics” by Murray and Dermott. You’ll need the latter eventually if you’re seriously interested in dynamics, though the coverage goes way beyond what is needed for this class.

**ABSENCES:** I will be away Thursday September 11<sup>th</sup> (at a supercomputing review panel), and the entire week of October 27<sup>th</sup> (lecturing at a summer school in Rio – it’s a tough life!). We will probably make up those classes later rather than having a substitute lecturer. If *you’re* away, for example for meetings or observing, that’s not a problem – let me know and we can make sure nothing vital is missed.

**EVALUATION:** Grading will be based on regular problem sets (60%) and two projects:

1. A numerical / computational project on the evolution of protoplanetary disks (15%).
2. A dynamics project: use existing code *or* analytic methods to solve some problem in planetary dynamics (25%, due end of the semester). For this third project you can work either individually or in groups of two (with appropriately loftier goals if you choose to collaborate), and may present your results either as a short paper *or* via an oral presentation which we’ll schedule as an additional session in the afternoon or evening during the last week of the semester.

**EXAMS:** None.

**QUERIES:** Questions and discussion in class are welcome – the more the merrier! Especially this year we have a very wide range of backgrounds in the class, including planetary scientists, astrophysicists and geologists, so speak up if I fail to define terms or assume “obvious” things that are not obvious to you. I would like this class to be a lively dialog on topics of mutual interest, so please read ahead and come prepared with any ideas or questions you want to discuss.

**STUDENTS WITH DISABILITIES:** If you qualify for accommodations because of a disability please submit to me a letter from Disability Services so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities.