

ASTR-, PTYS-450/550 — Fall 2023

The Origin of the Solar System and Other Planetary Systems

This class is scheduled to be taught in the in-person modality.

Meeting time: Tuesday & Thursday 9–10.15am

Location for in-person classes: Space Sciences 312

Instructor: Dr. Ilaria Pascucci (ilariapascucci.com)

Office hour: Tue 3-4pm (by appointment)

Course Description

This course will review the physical processes related to the formation and evolution of the protosolar nebula and of protoplanetary disks. In doing that, we will discuss the main stages of planet formation and how different disk conditions impact planetary architectures and planet properties. We will confront theoretical models of disk evolution and planet formation with observations of circumstellar disks, exoplanets, and the planets and minor bodies in our Solar System.

Course Objectives and Topics:

Upon completion of this course, students will know which physical processes shape planetary systems, understand observations of disks and exoplanets, and be able to place the Solar System into context. Topics covered in class include:

- The Solar System vs Discovered Planetary Systems: similarities and differences between the planets in our Solar System and exoplanets
- The Solar Nebula Theory: collapse of rotating clouds, the angular momentum problem, viscously accreting disks, irradiated disks, theoretical vs observed disk properties
- Disk Evolution and Disk Dispersal Mechanisms: viscous evolution, internal and external photoevaporation, disk and stellar winds, planet formation, theoretical vs observed evolutionary pathways
- Condensation and Growth of Solids: predicted and observed timescales for grain growth in the solar nebula and in protoplanetary disks, dust settling, radial drift of solids and the meter-size barrier to form planetesimals
- Main Planet Formation Scenarios: core accretion, disk gravitational instability and pebble accretion, observations testing these scenarios
- Planet Migration in Gaseous Disks: type I and II migration and their role in interpreting the properties of giant planets, Neptunes, and super-Earths

– Planetary Systems vs Stellar Masses: stellar-mass-dependent disk properties imprinted in planetary architectures and planet properties. Discussion on the potential of forming terrestrial planets in the habitable zone of A- down to M-dwarf stars

Expected Learning Outcomes. All students will be able to:

1. Summarize the key physical processes involved in the formation of rocky and gaseous planets
2. Use those key physical processes to explain the observations of disks and exoplanets
3. Place the planets in our Solar System in the context of extrasolar planets

Graduate students will be also able to:

5. Quantitatively describe how planet formation scales with stellar mass

Pre-requisites: All students enrolled in the astronomy, physics, planetary science, and optical science PhD programs can take this class. Students in other PhD programs should contact the instructor for approval. Undergraduate students who have taken Calculus (“Math 129: Calculus II” or equivalent) and two upper division science classes are also eligible to take this class.

Grades for both graduate and undergraduate students will be based on homework (70%) and one final exam (30%). Extra points will be given based on participation. This course uses absolute grading. If your final percentage falls within the following ranges, you are guaranteed at least the corresponding letter grade

A:87.5-100%; B: 75-87.5%; C: 62.5-75%; D: 50-62.5%; E<50%

Homework (graduate vs undergraduate)

Homework assignments will be announced in class and will be posted on the d2l website after the class. While the number of homework is the same for graduate and undergraduate students (4-5), the graduate student assignments will include more quantitative problem sets than those of undergraduate students. Homework assignments are graded on a 10-point scale. Late homework that are turned in the day after the due date will receive a 25% penalty while homework submitted later will receive a 50% penalty. Any homework submitted later than the first class after the due date will not be accepted. You are encouraged to work together but the work that you submit MUST be your own. Additional instructions: You can solve problems on scratch paper but before submitting your answers make sure to clean up your steps and write them down clearly (e.g. on white/ruled papers, word document, latex compiled pdf). Answers without steps will not receive credit. Label the number of each problem and sort your answers in the same order as in the posted homework.

Exam (graduate vs undergraduate)

There will be a final exam covering material discussed in class and in the homework. The exam is expected to take place in Space Sciences 312. The exam will contain a few advanced questions for graduate students only.

Makeup Exams

Makeup exams are only allowed for the following reasons and must be taken within 2 weeks of the exam date:

4. University approved activity (dean's approval required);
5. Religious holidays (you must provide information on the holiday);
6. Medical emergency, for which you can provide a doctor's note;
7. Jury duty.

Suggested textbooks:

There are no required textbooks for this class. The following textbooks are suggestions as to where students might look for extra information on the topics covered in class. These books will be put on reserve at the LPL library (Space Sciences 409):

"Accretion Processes in Star Formation" by L. Hartmann (Cambridge Astrophysics)

"Astrophysics of Planet Formation" by P. Armitage (Cambridge University Press)

"Protoplanetary Dust" by D. Apai and D. Lauretta (Cambridge University Press)

"Planetary Sciences" by I. de Pater and J. Lissauer (Cambridge University Press)

Classroom Participation Policy and Attendance: Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Although attendance will not be formally taken in this class, extra points will be given based on participation (see **Grades**) and will affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class activities, please contact me as soon as possible. A student's request for reasonable religious accommodations will be granted, please see <http://policy.arizona.edu/human-resources/religious-accommodation-policy> for details.

However:

– If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.

If you will be missing a course meeting or an assignment deadline, notify me immediately. Non-attendance for any reason does not guarantee an automatic extension of due date or rescheduling of examinations/assessments. If you must miss the equivalent of more than one week of class, you should also contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.

Academic advising: If you have questions about your academic progress this semester, please reach out to your academic advisor (<https://advising.arizona.edu/advisors/major>). Contact the Advising Resource Center (<https://advising.arizona.edu/>) for all general advising questions and referral assistance. Call 520-626-8667 or email to advising@.arizona.edu

Life challenges: If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The [Dean of Students Office](#) can be reached at (520) 621-2057 or DOS-deanofstudents@email.arizona.edu.

Physical and mental-health challenges: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520) 621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see: <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. The use of generative artificial intelligence (AI) is allowed for learning purposes (but be aware that AI is not trained in the topic of this course!). Note that incorporating any part of an AI-written response in an assignment is not allowed as it will be considered a violation of the Code of Academic Integrity. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <https://deanofstudents.arizona.edu/policies/code-academic-integrity>

Safety on Campus and in the Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): <https://cirt.arizona.edu/case-emergency/overview>

Also watch the video available at https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/common/learningeventdetail/crtfy000000000003560

University Policies

For other university policies please see:

<https://academicaffairs.arizona.edu/syllabus-policies>

Students with Disabilities:

If you anticipate barriers related to the format or requirements of this course, please meet with me so that we can discuss ways to ensure your full participation in the course. If you determine that disability-related accommodations are necessary, please register with Disability Resources (621-3268; drc.arizona.edu) and notify me of your eligibility for reasonable accommodations. We can then plan how best to coordinate your accommodations.

Subject to Change Notice

Information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor of this course.

Graduate Student Resources: <http://basicneeds.arizona.edu/index.html>