



PTYS/ASTR 416-516: ASTEROIDS, COMETS AND KBOs

Kuiper 312 (in-person) and Kuiper 330 (Zoom livestream)

Tuesdays and Thursdays 11AM – 12:15PM

Description of Course

Asteroids, Comets and Kuiper Belt Objects are the remnants of the process whereby small bodies formed in the protoplanetary disk and accumulated to become the Dwarf, Terrestrial, and Jovian planets. They are effectively time machines with physical characteristics and orbital properties that allow us to constrain the temperature, density, composition, and organization of the disk and provide insight into the timing and regions of planetary formation. In the final stage of planetary formation, a combination of gravitational scattering and migration dissipated most of the primordial planetesimal population, with the remaining objects confined to small number of stable reservoirs.

In this course, we will explore how studies of small bodies as a function of composition, location, source region, impact history, and evolutionary state are employed to disentangle their complex dynamical history and connect to the earliest epoch in the history of our solar system.

Instructor and Contact Information

Prof. Pierre Haenecour

Office: Kuiper 533

Email: haenecour@arizona.edu (putting PTYS/ASTR 416/516 in the subject line is appreciated)

Virtual office hours (through Zoom): schedule by email appointment (no regular in-person office hours)

Course website on D2L

Course Format and Teaching Methods

Most class meetings will be built around reading assignments. In addition to traditional lectures, there will also be open discussions and student-led presentations, according to topic and material. Students will be expected to be prepared with the material assigned prior to each class. Although no formal attendance record will be made, class participation will be part of the grade, and homework assignments are likely to make more sense if you've been to class.

Class Format: ***Flex In-Person***

Tentative schedule for the teaching format:

- *Phase I & II* - from August 24th to September 07, 2020: Live Online (Zoom through D2L)
- *Phase III* – from September 08, 2020: Flex In-person (however we won't start in-person class until the new seven-day rolling average of infection rate within Pima County drop below two per 100 K population). For this option, the class will be divided into two groups that will alternate between Tuesday and Thursday lectures:
 - Group-1 (12 students) attend the lecture in-person in Kuiper 312
 - Group-2 (12 students) attend the class remotely via Zoom (livestream will be available in Kuiper 330)
- *After Thanksgiving break* (Nov 30 - Dec 09): Live Online (Zoom through D2L)

All the meeting times for both remote and in-person teaching will be on the originally scheduled times: Tuesdays and Thursdays from 11AM to 12:15PM. It is important to note that, while the course will operate as flex in-person mode, we must be ready to adapt as the pandemic changes. We ask that you remain patient and flexible this semester. The class will be only meeting remotely until the COVID-19 situation permits safe teaching and learning on campus.

Zoom recordings and course slides/material will be posted only on D2L after each lecture. Student(s) who decide to attend the class using the Online Asynchronous option (Zoom video recordings) notify the class instructor by email. Students should contact the instructor if they do not wish to be identified by name on the recordings. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.

Students will also have the option to participate to group activities outside of the classroom (see information below).

Requirements for In-person Teaching

Face coverings are required in all classroom: Per UArizona's Administrative Directive, face coverings that cover the nose, mouth, and chin are required to be worn in all learning spaces at the University of Arizona (e.g., in classrooms, laboratories and studios). Any student who violates this directive will be asked to immediately leave the learning space, and will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the classroom until the matter is resolved.

The Disability Resource Center is available to explore face coverings and accessibility considerations if you believe that your disability or medical condition precludes you from utilizing any face covering or mask option. DRC will explore the range of potential options as well as remote course offerings. Should DRC determine an accommodation to this directive is reasonable, DRC will communicate this accommodation with your instructor.

Physical distancing is required in our classroom: During our in-person class meetings, we will respect CDC guidelines, including restricted seating to increase physical distancing and appropriately-worn face coverings. Per UArizona's Administrative Directive, face coverings that cover the nose, mouth, and chin are required to be worn in all learning spaces at the University of Arizona (e.g., in classrooms, laboratories and studios). Any student who violates this directive will be asked to immediately leave the learning space, and

will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the learning space until the matter is resolved.

Classroom attendance:

- 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.
- Notify your instructors if you will be missing an in-person or online course.
- [Campus Health](#) is testing for COVID-19. Please call (520) 621-9202 before you visit in person.
- Visit the [UArizona COVID-19](#) page for regular updates.

Academic advising: If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed.

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.

Course Objectives

The course will explore how studies of small bodies as a function of composition, location, source region, impact history, and evolutionary state are employed to disentangle their origin, complex dynamical history and connect to the earliest epoch in the history of our solar system. It will also introduce the techniques (*e.g.*, ground-based observations, space missions and sample laboratory analysis) used to study them.

Expected Learning Outcomes

By the end of the course, students will have developed an appreciation for the study of small bodies in the Solar System. They should have a refined understanding of the current state of knowledge for the composition, location, source region, origin, impact history, and evolutionary state of small bodies in the Solar System, as well as the techniques used to study them.

Equipment and software requirements

For the lectures and activities attended as Live or Asynchronous Online, students will need access to a web-enabled device in order to attend the live Zoom sessions and be able to download the course materials (Zoom recordings and presentation slides). Contact the instructor if you have any question/concern about the required equipment.

Absence and Class Participation Policy

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance (through one of the three options: in-person, live online, asynchronous online) is

required at all lectures and discussion section meetings. Absences may affect a student's final course grade. The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at: <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>.

If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible.

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://deanofstudents.arizona.edu/absences>.

The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable, <http://policy.arizona.edu/human-resources/religious-accommodation-policy>.

Assignments are due at the time of the class on their due dates. Late work will be accepted, although students should expect reduced credit. If a student anticipates an absence on the due date of an assignment, please either turn in your work early or discuss alternative arrangements with the instructor.

To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu.

If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

Makeup Policy for Students Who Register Late

Late course registrations will be considered on a case-by-case basis. Student who want to register late to the course should email the instructor to discuss potential options (and the timeline) to make up missed assignments/quizzes

Course Communications

Online communication will be conducted through official UA e-mail address and D2L. Students are encouraged to email the instructor about any question and/or concern.

Required Texts or Readings

No required textbook. Reading assignments (including review papers or book chapters) will be posted on D2L. Recommended optional books (listed below) are available online through the University Library:

- Elkins-Tanton, Weiss, Elkins-Tanton, Linda T., and Weiss, Benjamin P. *Planetesimals: Early Differentiation and Consequences for Planets*. 2017. Cambridge Planetary Science Series.
- Burbine, Thomas H. *Asteroids: Astronomical and Geological Bodies*. 2017. Cambridge Planetary Science Series; 17.
- Powell, Jonathan. *Cosmic Debris - What It Is and What We Can Do About It*. 2017. Springer International Publishing.
- Cunningham, Clifford J. *Investigating the Origin of the Asteroids and Early Findings on Vesta Historical Studies in Asteroid Research*. 2017. Springer International Publishing.
- Moltenbrey, Michael. *Dawn of Small Worlds: Dwarf Planets, Asteroids, Comets*. Cham: Springer International, 2016. Astronomers' Universe. Web.

Resources, such as E-books and review papers, will be made available on D2L under the 'resource' tab.

Extracurricular Activities

Students will be encouraged to participate in at least one of the proposed extracurricular activities:

- (In-person) Telescope viewing on the UA Mall (Date: TBD)
- (Live Online) Zoom viewing night from Mt Lemmon telescopes (Date: TBD, but probably in September)
- (Live Online) Events about the Solar System from the Open Space Project:
<https://www.openspaceproject.com/upcoming-events>
- (Asynchronous Online) Observation of meteorites using the meteorite virtual microscopes:
<https://www.virtualmicroscope.org/content/europlanet-meteorites>
- Stellarium (free open-source online planetarium): <http://stellarium.org>

Depending on the evolution of the restrictions associated with COVID-19, additional in-person activity opportunities might be added during the semester.

Tentative Scheduled Topics/Activities

The topics in logical units in a weekly schedule, including assignment due dates and exam dates are listed below for information. The workload, topics and course requirements are subject to change at the discretion of the instructor (with proper notice to the student) depending on the COVID-19 pandemic conditions and University decisions regarding in-person and remote teaching.

Week/Day	Topic(s)
Week 1 - Aug 25 & 27, 2020	Course introduction + Formation of the solar system and protoplanetary disks
Week 2 – Sept 1 & 3, 2020	Mechanisms of planetesimal and planet formation
Week 3 – Sept 8 & 10, 2020	Asteroids
Week 4 – Sept 15 & 17, 2020	Comets
Week 5 – Sept 22 & 24, 2020	Other Small Solar System Objects
Week 6 – Sept 29 & Oct 1, 2020	Asteroidal Samples
Week 7 – Oct 6 & 8, 2020	Cometary Samples
Week 8 – Oct 13 & 15, 2020	Volatiles (Origin, Composition and Transport) + Processing of asteroid surfaces - space weathering (guest lecture: Dr. Michelle Thompson)
Week 9 – Oct 20 & 22, 2020	OSIRIS-REx Sampling update & History of Spacecraft Missions to Asteroids and Comets
Week 10 – Oct 20 & 22, 2020	NASA Stardust (Comet Wild2) and ESA Rosetta Mission (Comet 67P/Churyumov–Gerasimenko) + Caesar mission concept
Week 11 – Oct 27, 2020	<i>Continue comet mission review</i>
Oct 29, 2020	First Quiz
Week 12 – Nov 3 & 5, 2020	<i>Two Graduate Student Presentations</i>
Week 13 – Nov 10 & 12, 2020	<i>One Graduate Student Presentation</i> + NASA NEOWISE and NEO Surveyor missions (guest lecture: Dr. Amy Mainzer)
Week 14 – Nov 17 & 19, 2020	<i>Two Graduate Student Presentations</i>
Week 15 – Nov 24 & 26, 2020	Thanksgiving Break
Week 16 – Dec 1 & 3, 2020	Upcoming missions – LUCY, AIDA (AIM+DART), Psyche
Week 17 – Dec 8 & 10, 2020	Summary/question session
Week 18 – Dec 15, 2020	Final Examination

Assignments and Examinations: Schedule/Due Dates

Assignments:

- **Undergraduate Students** will write a three-page paper during the semester. Students will select the topic of their paper based on a list of subjects that will be provided at the beginning of the semester. The paper will have to be submitted before Thanksgiving Break (by November 24, 2020).
- **Graduate Students** will give a one-hour presentation on one of those space missions: JAXA Hayabusa, NASA OSIRIS-REx, NASA Dawn, NASA New Horizon and NASA NEOWISE. The presentations will be scheduled for the first two weeks of November during the regular lecture times (hosted in-person or live-online depending on the status of the pandemic and University decisions).

Detailed instructions about the assignments will be provided at the beginning of the semester.

Students will also write a one-page summary of their experience and what they learnt the extracurricular activities. Details about the requirements for each activity will be provided during the semester.

All the assignments/papers should be written using letter-size page (1-inch margins), 1.5 spacing and Times New Roman font (or similar) with a 12-pt font size.

Final Examination or Project

The Final Exam will be on December 15, 2020 between 10:30 AM– 12:30 PM. Description of the Final Exam Regulations and the Final Exam Schedule can be found at

<https://www.registrar.arizona.edu/courses/final-examination-regulations-and-information>, and <http://www.registrar.arizona.edu/schedules/finals.htm>, respectively. Details about the format of the exam will be provided during the semester.

Grading Scale and Policies

Students will be assessed based on:

- Final Examination (date: December 15th, 2020)
- Mid-semester Quiz (tentative date: October 29th, 2020)
- Homework: homework exercises and reading assignments will be assigned based on the concepts and techniques described in lecture.
- (For Undergraduate Student only) - Writing assignment(s).
- (For Graduate Student only) - Class Presentation about a current/previous space mission.
- Extra-curricular Activities: Students are encouraged to attend at least one of the proposed activities above.
- Class Participation. For in-person/live online classes: the participation will be judge based on both the class and office hour participation. For asynchronous online: the participation will be judge based on the student participation to office hour participation.

The graded effort for:

- **Undergraduate Students:** Final Examination (30%), Mid-semester Quiz (20%), Homework and paper assignment (30%) Extracurricular activity (10%) and Class Participation (10%).
- **Graduate Students:** Final Examination (30%), Mid-semester Quiz (20%), Homework and class presentation (30%), Extracurricular activity (10%) and Class Participation (10%).

Grading Scale for the Course:

A — 90-100%	D — 60-70%
B — 80-90 %	E — 0-60%
C — 70-80%	

Incomplete (I) or Withdrawal (W)

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

Dispute of Grade Policy

The acceptable time period for disputing a grade on a paper/assignment, presentation, or quiz/exam is maximum a week after the grade has been posted onto D2L. The student must email the instructor to request a Zoom office hour call to discuss the disputed grade.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.). Please review the UA policy on disruptive behavior: <http://policy.arizona.edu/education-and-student-affairs/disruptive-behavior-instructional-setting>.

Students are asked to refrain from disruptive conversations with people sitting around them during lecture. Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion (or excluded from the Zoom call) and may be reported to the Dean of Students.

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, <https://drc.arizona.edu/>) to establish reasonable accommodations.

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. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism, available at <http://new.library.arizona.edu/research/citing/plagiarism>.

Zoom recordings are part of the students' educational record. Selling and/or sharing class notes, ZOOM recordings and/or other course materials to other students or to any third party is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy

The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Additional Resources for Students

UA Academic policies and procedures are available at <http://catalog.arizona.edu/policies>. Student Assistance and Advocacy information is available at <http://deanofstudents.arizona.edu/student-assistance/students/student-assistance>

Confidentiality of Student Records

<http://www.registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa?topic=ferpa>

Subject to Change Statement

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