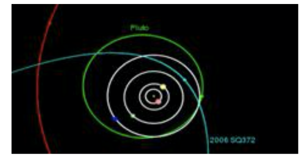
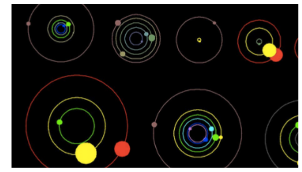
PTYS/ASTR 595B(002) Advanced Solar System Dynamics - Syllabus





Spring 2021: Tues, Thur 9:30-10:45 a.m.
Instruction Mode: Hybrid (Flex In-Person)
Classroom: Kuiper Space Sciences Building Room 301 or Room 330
First class meeting will be on January 14

Prof. Renu Malhotra
http://www.lpl.arizona.edu/~renu/
Kuiper Space Sciences 515; (520)626-5899; renu@lpl.arizona.edu
Office hours: By appointment. Owing to the current pandemic, I expect that in-office meetings will be rare, Zoom meetings will be the norm.

Course Objectives: This course will develop advanced skills in theoretical analysis and numerical methods for planetary orbital dynamics research, including modeling and interpretation of observational data of the solar system and exo-planetary systems. There will be applications to phenomena such as resonant and secular effects, scattering and long range transport, orbital stability and chaos of minor planets and of planetary systems as a whole. The course format is planned to consist of a combination of lectures, discussion of papers, and hands-on practice in a small group setting, including development of research project ideas and presentations of student research. This course is intended for graduate students; advanced undergraduates may be able to enroll with permission of the instructor.

Learning Outcomes: Students will gain knowledge of the diverse and rich phenomenology of planetary systems, and of the advanced mathematics and quantitative reasoning underlying modern understanding of and research on planetary systems. Students will be able to apply the concepts and principles of orbital dynamics to draw conclusions from observational data about planets and minor bodies in planetary systems, to engage with novel research ideas, and to demonstrate their proficiency in designing and carrying out quantitative research in this field.

Pre-requisite(s): PTYS/ASTR 553 Solar System Dynamics (or equivalent). Students should also be (or become) proficient in a programming language and graphics software (examples: Fortran, C, Ruby, Python, Julia, GnuOctave, Matlab).

Class Web Page: You will need a UA Net ID to access the class web page at the UA's D2L website, http://d2l.arizona.edu. I will use the class webpage to post class notes and other communications. This webpage will be updated frequently throughout the semester.

Required Texts and Materials: "Solar System Dynamics", by C.D. Murray and S.F. Dermott, Cambridge University Press, UK, 1999. It is available in hardcover, paperback and electronic book. Upon enrolling in this course, a student automatically has access to the electronic book through the UA; for cost and access information, please carefully read "Syllabus Inclusive Access Information" posted on the class webpage at D2L. We will also often use additional literature, including research publications and drafts of notes from the instructor and other experts in the subject; these materials will be made available to students, and students must respect the intellectual property rights of such materials.

General Schedule and Activities: An approximate schedule of topics to be covered is attached at the end of this syllabus. There will be reading assigned prior to most class meetings; class meetings will usually consist of discussion of the assigned reading. Some class meetings will include practice with calculations and with computer codes on current research topics, some led by the instructor, some by students (and may include guest lectures from expert colleagues). There will be a midterm take-home assignment due approximately 03/11/2021. By mid-March, each student will also identify a topic for their final project, and will subsequently lead a 25-minute discussion about a paper (or other literature) serving as background to that project; the student is expected to distribute the discussion materials ahead of time and come prepared to lead the discussion in class. The final one-to-two weeks are reserved for student presentations of their projects.

Assessments: The grade will consist of three components: *Midterm exam (25%), in-class participation (25%), Final paper (50%)*. The midterm exam will consist of a combination of assigned and student-initiated problem-solving. (Re-writes will be allowed for 50% additional credit; for example, 80% on the midterm and 100% on the rewrite will earn 90%.) For the in-class participation assessment, students will be graded on preparedness and engagement with class discussions. The final paper is in lieu of the final exam. The final paper will be graded for clarity, rigor, quantitative basis, completeness, presentation and how you field questions and manage the class discussion of your presentation.

Grading scale: Regular letter grades are awarded for this course, with a default grading scale of: A — 85-100%, B — 70-84%, C — 55-69%, D — 40-54%, E — 0-39%. The instructor reserves the right to adjust the grade boundaries based on her expectations of student performance.

UA Academic Policy notice: All university policies related to a syllabus are available at: https://academicaffairs.arizona.edu/syllabus-policies**.** I expect students to be ethical, and to be cognizant of and to abide by the relevant policies on academic integrity and classroom behavior, and the use of University and course resources.

Additional UA conditions for in-person meetings during the current pandemic situation:
Physical distancing and face-coverings 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.

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.

Subject to Change Statement: The workload and course requirements other than the grading and absence policy are subject to change at the discretion of the instructor with proper notice to the students.

Approximate schedule of topics (subject to change):

Review of the two body problem, Canonical elements, Perturbations

Numerical orbit propagation

The restricted three body problem, Jacobi integral, Lagrangian equilibrium points, zero velocity curves, surfaces of section

Review of phenomenology of the solar system and exoplanetary systems

The N-planet problem - numerical methods, hybrid symplectic integrators

Hills problem

Mean motion resonance - physics, geometry, perturbation theory, single resonance theory, periodic orbits, adiabatic evolution and capture in resonance, resonance overlap and chaos, numerical treatment, surfaces of section

Secular dynamics of hierarchical triples - Lidov-Kozai effect, adiabatic evolution

Secular evolution in the N-planet problem - Laplace-Lagrange linear perturbation theory, N=2, N>2. Milankovich theory

Secular resonance (of test particle, of planets)

Chaos indicators

Planetary spins, coupled spin-orbit dynamics