Pan-STARRS-1 (PS1) is a 1.8m aperture telescope located in Maui on Haleakala. With its 1.4 gigapixel, 7 square degree camera, PS1 will repeatedly image the entire sky north of -30 degrees declination. The three and a half year PS1 science mission will begin in the spring, 2009. Roughly 60% of the observing time will be dedicated to a "3pi steradian" survey with an observing cadence that is well-suited to the detection of outer solar system objects. This unprecedented survey will discover nearly every Trojan, Centaur, long-period comet, short-period comet, and trans-neptunian object (TNO) brighter than the PS1 detection threshold (r=22.3) that is within the survey region. This census will be used to address a large number of questions regarding the physical and dynamical properties of the various small body populations of the solar system.

The Harvard-Smithsonian Center for Astrophysics is a member of the PS1 Science Consortium, which will operate the telescope. Holman is the lead of the PS1 Outer Solar System Key Project and is in a good position to involve graduate students in the research opportunities that PS1 presents.

We, Holman and Murray-Clay, propose an upper level course to help graduate students, and possibly undergraduates, get involved in this type of research. The idea would be to give students the tools needed to initiate and complete substantial investigations of the outer solar system with data from Pan-STARRS-1. With the flow of data from PS1 beginning in spring, 2009, it would be good to offer the course in that semester so that students will be ready to go as the data start to arrive.

The course would be a hybrid between a formal lecture course and a research seminar series. The lectures would introduce the analytic and numerical techniques of modern solar system dynamics. The topics would include: Lagrangians and Hamiltonians; averaging and canonical transformations; the two-body, three-body, and n-body problems; the development of the disturbing function; secular evolution; mean-motion resonances; resonance overlap and chaos; and numerical integration techniques. This material would be presented in a way that applies to our own solar system as well as to extrasolar planetary systems.

The research seminar component of the course would focus on developing projects that apply the tools of solar system dynamics, at a range of levels of sophistication, to the data from PS1. The projects will be developed with the expectation that the first year of Pan-STARRS-1 data will permit the publication of substantial outer solar system investigations that will not be supplanted until the LSST becomes operational.

Instructors:
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Course Format:
The first half of course will comprise formal lectures on solar system dynamics, relevant outer solar system topics, and background related to the Pan-STARRS-1 surveys. The second half of the course will comprise less formal presentations and group discussion of the research projects selected by the students.
Class Hours:
Classes will be held twice per week for 1.5 hours each class.

Office Hours:
Meetings with the instructors are by appointment.

Prerequisites:
An upper level course in classical mechanics would be helpful but not required.

Expectations and Evaluations:

• Class participation and presentation
  Since discussion is an integral part of this course, we expect all students to participate.

• Problem sets (50%).
  The problem sets are designed to reinforce the material and to help the students develop an understanding of the physics that underlies various aspects of solar system dynamics. Between 4 and 6 problem sets will be given.

• Research project presentations (20%).
  Each student will give two presentations on the research project they select. In the first of these the student will describe the goals of their project and the relevant background.

• Write-up of final project (30%)

Sample Projects:

• Determining the plane of the Kuiper belt.
• Determining the radial extent of the Kuiper belt.
• Characterizing the Inner Oort Cloud and Sedna-like populations.
• Determining the intrinsic abundance and dynamical properties of the Neptune Trojans.
• Determining the intrinsic abundance and dynamical properties of the 3:2, 2:1, and other resonance populations.
• Determining the inclination distributions of the various dynamical classes in the outer solar system.
• Finding collisional families in the outer solar system.
• Determining the frequency of contact binaries in the Kuiper belt.

Recommend Texts:
These books are available on amazon.com.