Hunting for Extra-Solar Planets (HSSP Spring 2010)

Course Description:

Who will discover the next planet around another star? It may be you! Unlike projects like Folding@Home or SETI@Home designed by scientists who want to use your computer to crunch their data, the world's premier planet hunting team at Lick Observatory wants to use your brain. Come learn how astronomers combine the celestial mechanics developed by Kepler and Newton with data from the latest telescopes and NASA missions to discover planets around other stars. You will receive all the training you need to use the *Systemic Console* — a free piece software developed by astronomers at Lick — to search for new extra-solar planets by analyzing radial velocity measurements.

Class Sessions:

Session 1, April 17th: Introduction to the Search for Extra-Solar Planets

Learning Objectives:

- The student will understand the scope of our current knowledge of extra-solar planets, including how many have been discovered, the major detection methods, and what we can deduce about extra-solar planets' physical properties.
- The student will understand how amateurs around the world can work together to discover extra-solar planets using the *Systemic Console*.
- The student will master the basics of the *Systemic Console*, including how to open and display data files and access the tools for modeling planetary orbits

Lecture: Introduction to the Search for Extra-Solar Planets
Activity: Exploring the *Systemic Console*.

Session 2, April 24th: Celestial Mechanics 101: Modeling Planetary Orbits

Learning Objectives:

- The student will master the definitions of the orbital elements used to model planets' orbits.
- The student will connect properties that define a planet's orbit – including the planet's mass, orbital period, and orbital eccentricity -- to the measured wobbles of its host star.
- The student's will master modeling planets in the *Systemic Console* using Kepler's laws of motion
- The student will use the *Systemic Console* to detect a planet orbiting the star HD 4208.

Lecture: Kepler's Laws and the Basics of Planetary Orbits
Activity: *Systemic Console* Tutorial #1

Session 3, May 1st: Now Entering Frequency Space: Finding Multi-Planet Systems

Learning Objectives:

- The student will understand how a star's interactions with several planets superimpose and cause it to wobble at several different frequencies

- The student will gain a conceptual understanding of a periodogram and a practical understanding of using the *Systemic Console* periodogram to detect the orbital frequencies of multiple planets
- The student will use the *Systemic Console* to detect three planets orbiting the star Upsilon Andromedae.

Lecture: Frequencies and Periodograms
Activity: *Systemic Console* Tutorial #2

Session 4, May 8th: When [Don't] Worlds Collide: Gravitationally Interacting Planets

Learning Objectives:

- The student will understand how planets' interactions with each other affect their orbits and perturb the orbit of the star
- The student will understand how special orbital configurations enhance gravitational interactions between planets
- The student's will master modeling planets in the *Systemic Console* using Newton's laws of motion
- The student will use the *Systemic Console* to detect a pair of strongly interacting planets orbiting the star GJ 876

Lecture: Newton's Laws and Planets' Gravitational Interactions
Activity: *Systemic Console* Tutorial #3

Session 5, May 15th: Planet or Noise? Statistical Tools for Detection

Learning Objectives:

- The student will understand the sources of noise for radial velocity measurements of the star's wobbles
- The student will master statistical tools for assessing models of planetary orbits, including the False Alarm Probability test and the bootstrap method.
- The student will use the *Systemic Console* to detect three planets orbiting the star 61 Virginis and assess their model using the False Alarm Probability test and the bootstrap method.

Lecture: Noise and Uncertainty: Assessing Our Models
Activity: *Systemic Console* Tutorial #4