Course Outline

The course will roughly divide into three main parts:

- Introduction (1 week),
- Topics covered in the Heteroclinic paper (3 weeks), and
- Numerical issues related to the Genesis mission and Shoot the Moon (4 weeks). In the last week, the students will present their class projects.

1st Week:
Introduction.

1. *Monday, March 27.* Overview of the Heteroclinic paper, focusing on the Genesis mission, Shoot the Moon, temporary capture and resonance transition of Jupiter comets as well as the Petit Grand Tour of Jovian moons. This lecture will serve as an introduction to the materials that will be presented in the next 3 weeks.

2. *Friday, March 31.* 2nd lecture will give an overview of the Genesis mission and all the related theoretical and numerical problems, such as center manifold, Lindstedt-Poincaré method, computation of invariant manifolds, numerical integration of the end-to-end trajectory through differential correction, optimal control and station keeping, etc. This lecture will serve as an introduction to the materials that will be presented in the last 4 weeks.

2nd Week:
Basic features of CR3BP.

1. *Monday, April 3.* Equations of motion (using both Langrangian and Hamiltonian approaches). Jacobi constant. Equilibrium points and their stability. Energy manifold and Hill's region.

2. *Friday, April 7.* Orbit structure in the equilibrium region: periodic, asymptotic, transit and non-transit orbits. Invariant manifolds as separatrices. McGehee representation. Flow mappings in the equilibrium region and their consequences. The appearance of orbits in the position space.

3rd Week:
Global Orbit Structure of Planar CR3BP.

1. *Monday, April 10.* Homoclinic and heteroclinic orbits. Their importance in the study of the global orbit structure. Brief mention of the numerical methods for finding the Lyapunov orbits and their invariant manifolds. Numerical construction of homoclinic and heteroclinic orbits.

2. *Friday, April 14.* The lecture will use standard textbook examples to illustrate the basic concepts underpinning the Main Theorem of the ''Heteroclinic'' paper, such as Poincaré map, symbolic dynamics, etc. It will cover the basic structure of the proof and the significance of the Main Theorem.

4th Week:

Applications in Astronomy and Space Mission Design.

1. *Monday, April 17.* Construction of orbits with given itinerary. A detailed description of the procedures used in the Petit Grand Tour.

2. *Friday, April 21.* Application to resonant transition of Jupiter comets. Delaunay variables. Interior and exterior resonances and their connections. Furture work.

5th Week

Halo orbits and its Computation.

1. *Monday, April 24.* The importance of halo and quasi-halo orbits for space mission. Analytical expansion (1st order and 3rd order Richardson). Bifurcation (Lyapunov orbit bifurcates into halo orbits).

2. *Friday, April 28.* Differential correction. Numerical computation of halo orbits. May include the orbit structure near an equilibrium point.

6th Week:

Invariant manifolds and End-to-end Transfer.

1. *Monday, May 1.* The trajectory planning of Genesis mission. Computation of invariant manifolds.

2. *Friday, May 5.* Differential correction and the Computation of end-to-end transfer. May include some materials on the influence of the moon on the transfer.

7th Week:

Optimal control and TCMs. Station Keeping.

1. *Monday, May 8.* Merging optimal control with dynamical system and its application to trajectory correction maneuvers (TCM) in Genesis mission. May include an introduction to numerical optimization method: direct vs indirect; collocation vs shooting; SQP; sensitivity analysis.

2. *Friday, May 12.* Station keeping.

8th Week:

Further Applications: Shoot the Moon and Formation Flying.

1. *Monday, May 15*. Formation flying near a halo orbit.

2. *Friday, May 19*. The lecture on ''Shoot the Moon'' will be given in the ''Three-Body Fest''. Everyone is encourged to participate in this day-long mini-worshop.

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