National Aeronautics
and
Space Administration

Orbit Design for Exoplanet Missions

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Project Objective

Determine and characterize suitable orbits for missions to detect and study exoplanetary systems.

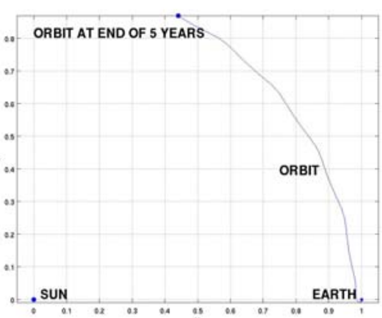
We want to send the most mass, use the least fuel to support single or multiple spacecraft in formation using chemical or low thrust propulsion.

Recent Results

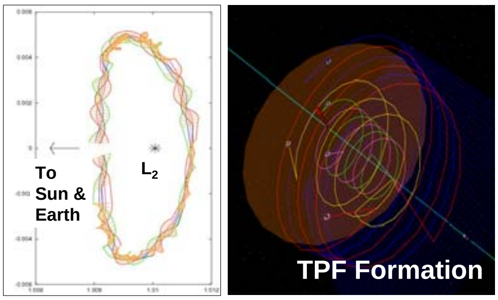
Recently we performed a study with other colleagues on an externally occulted coronagraph concept with 2 spacecraft. The results indicate that a low thrust mission in L_2 halo orbit to be the most favorable architecture. Chemical propulsion requires too much fuel and mass. Solar sail is infeasible. A low thrust mission in heliocentric orbit is feasible fuel-wise, but requires excessive long duration to complete the mission due to the time needed to move the occulter to successive stars. (see Fig. 3 & Cash [06]).

Project Description

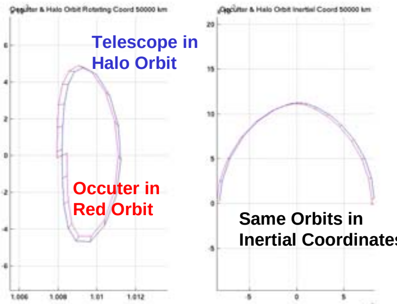
Exoplanet missions require a cold stable environment for observations. For planet detection, interferometry and coronography are the two methods of choice. Many of the mission architectures require multiple spacecraft in formation flight. Heliocentric orbits such as used by Spitzer (Fig. 1) and Halo orbits around L_2 proposed for the TPF interferometer mission (Fig. 2.) also planned for JWST are two of the best venues in space for such missions. Although the navigation in heliocentric missions is very minimal, the spacecraft will drift 1 AU from Earth after 5 years where communications becomes an issue due to the great distance. Also if multiple launches are required for formations, the rendezvous cost will be prohibitive. But for a single spacecraft mission, this is an attractive option. On the other hand, halo orbits do provide multiple launch opportunities and much cheaper formation reconfiguration and station keeping costs. This was the case for the External Occulter study (Fig. 3.)



1. Earth Leading Orbit



2. TPF Formation in Halo Orbit



3. External Occulter in Halo Orbit

Benefits to NASA and JPL (or significance of results)

We demonstrated that the best trajectory for an external occulter planet finder mission is a halo orbit around L_2. We also showed that for formations with large slews, solar sail is not practical. In general, low thrust propulsion seems to be the optimal approach for exoplanet missions in halo orbits or heliocentric orbits.

Publications

Lo, M., C.W. Yen, R. Russell, S. Campagnola, Terrestrial Planet Finder Occulter Study, 19 September 2007.

Cash, W., Detection of Earth-like planets around nearby stars using a petal-shaped occulter, Nature Vol 442, 6 July 2006.

Exoplanet Science and Technology Fair | **Von Karman Auditorium, JPL, 22 Feb 2008** | **Poster No. 27**
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