Paper ID: 12658
oral
student

From Earth Missions to Deep Space Exploration (05)
Poster Session (P)

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GAS GIANT EXPLORATION WITH E-SAIL

Abstract

Exploring the gas giant planets is considered as extremely challenging step towards cost-effective future space explorations. These type of missions put high demands on the propulsion system as relatively high velocity change is required. The Electric Solar Wind Sail (E-sail) could enable missions to gas giants where there is specific scientific interest for exploration of planets and different moons.

E-sail is a novel technology that uses long, thin and positively charged tethers to extract momentum from the solar wind. The positive charge is sustained by an electron gun which requires only moderate power to operate. Micrometeoroid resistant multi-line tether designs, for example four-fold Hoytethers or Heytethers, enable the effective use of kilometers long tethers. The tethers are kept straight by spin stabilization. To achieve dynamical stability of the sail without moving parts, the tips of the tethers are connected with non-conducting auxiliary tethers.

In traditional gas giant missions, precise choice of launch window is crucial to achieve the required number of planetary flybys to add for the needed velocity change budget of the mission. The simplest way of using the E-sail in giant planet missions (and applicable to all outer solar system missions) is to use it as a "slow booster" that replaces the conventional gravity assist manoeuvers with Venus, Earth and other planets, thus shortening the travel time and reducing the launch mass. E-sail could enable multiple cost-effective missions to explore gas giants and their moons. Due to the propellantless nature of E-sailing, the spacecraft only needs to be designed to operate in a specific solar distance range and have a certain lifetime. This makes the spacecraft design quite flexible towards launch windows and would enable to send multiple similar spacecraft to different target giant planets.

In a more advanced way, given that the giant planet magnetospheres contain a rapidly corotating plasma flow, it might also be possible to apply E-sailing for propulsion inside the giant planet systems. In the best case, this might eventually open up a way to travel to a giant planet moon and back by E-sailing alone, perhaps augmented by running the tethers in an electrodynamic tether propulsion mode over a portion of the mission near the giant planet.

This paper will present the results of a feasibility assessment of an electric sail mission design for unmanned exploration of gas giants.