Open Internship in the ESA Advanced Concepts Team in 2016
on

The Photon Grid - Propellantless Laser Control of Tethered Space Webs

Topic description

Several studies have indicated the potential of deploying large tethered webs in space [1, 2]. In this concept, a grid of light flexible ropes creates a highly distributed formation of satellites or individual payloads for sensing and observation. Such ultra-lightweight structures would enable extremely large apertures and very long baselines in order to deliver high resolution and bandwidth. Possible applications range from large reflector antennae to multi-platform space interferometers. Controlling the system's formation is complex, since the tethers cannot support compression forces, and the lifetime would be substantially limited by the amount of propellant required to maintain precise baselines. Alternative solutions include, for example, the use of centrifugal forces to pull the web.

Photonic Laser Thrusters (PLT), originally proposed in 2006 [3] could offer a stabilisation and control mechanism. This method uses laser photons trapped between mirrors on each spacecraft at the tips of the web. The photons travel many times between the mirrors, which greatly amplifies the photonic momentum. This “pushing-out” force, combined with the pulling-in force provided by the tensioned tethers, could stabilise the system and potentially enables propellant-free high-accuracy tethered formation flying.

This project shall investigate the use of laser momentum exchange for the deployment and the control of tethered space webs. It shall be analysed whether the system is able to counteract perturbations from the space environment such as, for example, solar pressure, magnetic- or gravity-gradient forces. In addition, open problems shall be addressed like the maximum range of a coherent laser beam as well as aiming, aligning, and tracking over long distances.

Candidate's tasks

The successful candidate will analyse whether a `photon grid' of lasers would stabilise the web in orbit. In addition, the power requirements in order to maintain sufficient tension shall be studied. The specific project tasks include:

- Model the configuration of tip-satellites (point masses), tethers (flexible chains of elements), and forces;
- Analyse the response of the web to relevant external forces acting on the system in Earth orbit;
- Study the system's feasibility for future space missions in terms of, for example, the robustness of control.

The ideal candidate

Mandatory

- B.Sc. in Physics or Space Engineering
- Interest in dynamical systems

Desirable

- Experience in numerical modelling and orbital dynamics

References

[1] Gärdsback, M., Tibert, G., and Izzo, D., Design Considerations & Deployment Simulations of Spinning Space Webs, Paper AIAA 2007-1829, 48th AIAA Structures, Structural Dynamics & Materials Conf., Honolulu, Hawaii, 2007. PDF Link

[2] Bergamin, L. and Izzo, D., Comments on Deployment and Control of Charged Space Webs, European Space Agency, the Advanced Concepts Team, ACT technical report (CDCCSW07), 2007. PDF Link

[3] Bae, Y. (2006) "A Contamination-Free Ultrahigh Precision Formation Flight Method Based on Intracavity Photon Thrusters and Tethers". Final Report, NASA. PDF Link