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PROJECT GLOWWORM: TESTING LASER SAIL PROPULSION IN LEO

Abstract

Laser sail propulsion is a promising concept for accelerating spacecraft to great velocities without the need for any propellant. However, despite the fact that this concept has been discussed for a long time, it has never been demonstrated in space. The Initiative for Interstellar Studies (I4IS) is developing the Glowworm mission which aims to conduct the first in-orbit demonstration of laser sail propulsion. Glowworm will consist of a CubeSat that deploys a small chipsat attached to a sail; the CubeSat will then use an onboard laser to push the sail and raise the orbit of the chipsat; the mission is targeting a semi-major axis increase of 10 km. This paper describes two concepts for how to achieve this. The first concept has the CubeSat maintain its position relative to with the sail using an electric propulsion system, while the second has the CubeSat remain in its original orbit and use the laser to raise the sail periodically when they pass near each other.

A simulation of both concepts is described which uses NASA's General Mission Analysis Tool (GMAT) and a baseline 800 km circular sun-synchronous orbit (selected to minimize the influence of solar pressure which in certain orbits could exceed the thrust from the laser).

Results show that the second of these concepts is infeasible. Because the orbit raising achieved by each laser use interval is small, the frequency with which the two spacecraft come close to each other in their orbits is quite low. As the sail experiences drag in the intermediate time period, its orbit decays below the initial level between laser use windows unless a very high laser power is used. In addition, results indicate that, even with a laser power of 500 W focused over a distance of 200 km, the energy imparted to the sail would decay due to drag before the sail passed close enough to the CubeSat to use the laser again. Therefore, only the concept with propulsion included is viable to complete the Glowworm Mission.

The paper then describes preliminary analysis on this concept and presents an initial design.