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PASSIVELY STABLE RELATIVISTIC PHOTONIC SAILS DRIVEN BY DIRECTED ENERGY

Abstract

Directed energy photonic propulsion is a core technology to realizable interstellar relativistic travel, using photon pressure from a gigawatt-class ground or orbiting laser array to accelerate gram-scale spacecraft to 0.1c. This approach is being pursued by programs including NASA DEEP IN and Breakthrough Starshot.

The launch phase involves intense acceleration, of greater than 10,000 g over a few minutes in order to bring the spacecraft to relativistic speeds before the beam diverges significantly. Due to the mass and size constraints, it is unlikely the spacecraft will be able to steer during acceleration. Thus, the spacecraft is required to be trapped in the beam, which is accomplished both by shaping the sail and beam. There are a number of system trade-offs: for example, donut beams can trap a wider range of sail shapes, such as spherical, hemispherical and some conic sections. Trapping beams with nulls are more difficult to synthesize and are inefficient, while a Gaussian beam is easier to form, but often requires ballast mass at some distance away from the sail.

We present results from analytic and numerical modeling of the beam-sail interaction, showing trajectories and stability over multiple sail and beam shapes, mass distributions, trajectory disturbances, sail defects, and optical aberrations.

Our results dictate the geometric and mechanical requirements of interstellar laser sails, the necessary optical performance of the driving laser array, and achievable targeting precision.