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SAILING IN THE DARK : ASTEROID STATIONKEEPING WITH A PHOTON SAIL USING ASTEROID INFRARED EMISSIONS

Abstract

Both the scientific exploration and the prospecting of resources of Near Earth Asteroids (NEA) would benefit from visits to multiple bodies by a single spacecraft, for which a photon sail (typically called a solar sail when used in the sunlight) offers many advantages. However, it is not possible to truly turn off the thrust from a sail in full sunlight, which could cause considerable difficulties in station-keeping with small asteroids. While a solar sail can "cone" (rotate about the spacecraft-Sun line) reducing thrust by maintaining a considerable angle between the sail and the Sun, but small NEA have very weak gravitational fields, and even a sail kept at a 85 pitch angle to the Sun can have too much acceleration to be stably kept in proximity to a target asteroid. The existence of wrinkles and billows in real sails increases the thrust and further complicate Lagrange point stationkeeping in full sunlight.

However, most small asteroids are also rapid rotators, which distributes solar heating more or less uniformly across their equatorial surfaces. It is possible to show that, in the limit of fast rotation and a zero albedo, the infrared flux (and thus the momentum transfer) from such a body will be one fourth the solar flux and momentum transfer per unit steradian, with this flux being present even on the shadowed side of the body. As asteroid albedos are typically low, this limit can be approached by real bodies; asteroid photon thrust can certainly not be neglected for close spacecraft maneuvering. In addition, for the small asteroids of interest, neither the solar nor the thermal radiation pressure thrusts on the asteroid can be ignored in calculating small spacecraft maneuvers. These thermal thrusts raise the interesting possibility of photon sailing in the shadow of the asteroid, and will allow for station keeping fully or partially in the dark in some circumstances.

This presentation will focus on orbital maneuvers and station keeping for a small asteroid prospector using a photon sail, both for maneuvers completely in the shadow of a target asteroid, and for maneuvers using a mix of solar and asteroid photon thrusting.