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CLOSED-FORM SOLUTIONS FOR THE AVERAGED DYNAMICS OF HAMR OBJECTS

Abstract

High Area-to-Mass objects in high Earth orbit are known to be subject to strong solar radiation pressure effects in addition to higher-order Earth gravity field and luni-solar perturbations. The dynamics of these objects have been explored in the last few years with both numerical and analytical techniques, finding that extremely large excursions occur in eccentricity and inclination due to these combined effects.

We present and apply a new analytical closed-form solution for the averaged dynamics of HAMR objects subject to solar radiation pressure. This new formulation can give precise predictions on the maximum area to mass ratio that can survive for long durations in high-Earth orbit, and provides predictions of the secular evolution of these orbits that compare well with long-term integrations over many decades. The theory specifically solves for the angular momentum and eccentricity vector as functions of Earth true anomaly, and yields simple periodic motion in a frame rotating with the Earth-Sun line. Transformation of these solutions into the inertial Earth Equatorial frame is seen to account for the short and long-period oscillations observed in the secular orbits of these objects.

The paper we will present this model and its averaged solution, discuss its predictions, and make comparisons to existing numerical simulations. We also show how the formulation of this averaged result can be modified to incorporate perturbations from the Earth gravity field and 3rd body perturbations. Finally, we discuss modifications to the SRP-only solution due to perturbations from the Earth 2nd order gravity field and 3rd body perturbations.