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TUMBLING RATES OF INACTIVE GEO SATELLITES

Abstract

Space debris in any orbital regime poses an ongoing threat to space assets. Presence of debris in geosynchronous earth orbit (GEO) or near-GEO raises particular concern due to the importance of the operational satellites there, including communications, earth observation, and military satellites.

Understanding the behavior of objects that pose a threat to assets in the GEO belt motivates our investigation of inactive GEO satellites. This paper presents actual rotational rates of inactive satellites based on observations. The dynamics of these drifting and inactive satellites may change through collisions with other objects or torques induced by perturbations. The torques caused by re-emitted sunlight and thermal energy, known as the Yarkovsky, O'Keefe, Radzvieskii, and Paddack (YORP) effect, have been credited for the change in angular velocity of asteroids. This effect has recently been introduced for inactive satellites. Here we investigate the dynamics of inactive GEO satellites, and the evolution of their dynamics, through observation of their tumbling rates as a function of time.

The set of Geostationary Operational Environmental Satellites (GOES) known as GOES 8 - 12 present a nearly ideal test case for this investigation. Of almost identical construction, the five satellites were decommissioned at different times over a period of 9 years, from 2004 to 2013. The satellites drift westward around the earth at 4 to 5 degrees per day, providing ongoing opportunities for observation. In addition, the asymmetry exhibited by the geometry of these satellites makes them perfect candidates for the study of the YORP effect.

We have observed the defunct GOES with a small telescope with sampling periods on the order of seconds. We process the resulting images to determine the temporal change in flux reflected from each satellite, and analyze the temporal curve to determine each satellite's primary tumbling period. By taking observations at different points in time, we can determine the secular change of the angular velocity of these satellites. Modeled dynamics are then compared to the observations to determine the extent to which the YORP torques could be the cause of the observed rotation motion of the satellites.