Paper ID: 70665
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

Author: Mr. Masaki Kakeru
Kyushu University, Japan

Dr. Yasuhiro Yoshimura
Kyushu University, Japan
Prof. Toshiya Hanada
Kyushu University, Japan
Dr. Hongru Chen
Kyushu University, Japan

DYNAMICS AND STABILITY ANALYSIS OF SPACECRAFT ATTITUDE CONSIDERING HIGH-FIDELITY SOLAR RADIATION PRESSURE

Abstract

Solar radiation pressure (SRP) is a significant disturbance for probes in deep space missions. While the SRP is a slight force, its effect on spacecraft's orbit and attitude is accumulative. Since the SRP is available in the solar system and provides external force and torque, exploiting the SRP for satellite control enables fuel-free attitude and orbit control. The SRP is induced from sunlight reflections, and the magnitude and direction of the SRP depend on the satellite attitude, shape, and optical reflectance properties of the surface. Conventional formulations of the SRP assume that the reflections on the satellite surface are Lambertian and perfect specular. However, the actual surfaces of the satellite have more complicated reflection patterns depending on the optical reflectance properties, which yields different magnitude and directions of the SRP and SRP torque from conventional ones. As a result, the attitude stability of spacecraft with SRP torques is expected to change. In this context, this paper deals with the satellite attitude dynamics considering a more complicated reflection model of the SRP. Furthermore, the attitude stability analysis is conducted, and the dependency on the optical reflectance properties is presented. This paper uses a bidirectional reflectance distribution function (BRDF). The BRDF expresses a reflected light distribution, and the use of a physically based BRDF enables describing the more realistic SRP. This paper uses the Cook–Torrance model as BRDF and reveals the difference of the satellite attitude motion by SRP torques due to the optical reflectance properties in the Cook–Torrance model. The attitude dynamics derived in this paper are more realistic than conventional ones because the Cook–Torrance model is reduced to the conventional BRDF when parameters of optical reflectance properties in the Cook–Torrance model become zero. Furthermore, the derived attitude dynamics analytically provide attitude stability conditions and differences from the dynamics using the conventional SRP. The stability analysis, induced by eigenvalue and phase-plane analyses, is numerically verified and compared to the conventional model. The attitude dynamics proposed in this paper reveal insights into the effect of optical reflection properties on attitude stability.