Time variation of solar radiation pressure acceleration acting on geodetic satellites

*Akihisa Hattori[1], Toshimichi Otsubo[2]

1. Hitotsubashi University, Faculty of Social Science, 2. Hitotsubashi University

Solar radiation pressure is one of the major error sources in satellite geodesy. Solar radiation pressure acting on a satellite varies in accordance with how sunlight illuminates its surface and how it is reflected. The cannonball model widely applied for spherical geodetic satellites rests on the following assumption: the satellite is a perfect sphere and the optical properties of its surface is spherical symmetry. Applying this model, a solar radiation pressure coefficient C_R is often adjusted as a scale factor. This study focuses on the time variation of the C_R solutions.
We use the geodetic analysis software "c5++" (Otsubo, 2016) to estimate the C_R coefficients of the six geodetic satellites: Ajisai, LAGEOS-1, LAGEOS-2, LARES, Starlette and Stella. Satellite laser ranging data for the past 20 years are analyzed where the C_R coefficients are estimated per 30 days.
An interesting behavior is observed in the time series of Ajisai's C_R estimates. It ranges from 1.022 to 1.064, and shows a clear semiannual pattern maximizing in summer and winter. The 0.04 variation of Ajisai's C_R value is equivalent to a 1.0 nm/s^2 difference in the acceleration acting on the satellite (Hattori, 2016).
Sengoku et al. (1995) constructed a solar radiation pressure model of Ajisai based on its surface materials. The C_R is predicted to vary in a range from 1.020 to 1.035 and show a dominant annual pattern with a maximum in summer. This does not agree well with our solutions above.
We attribute the reason of the discrepancy to the following two facts. One is that a 5-cm-height metallic ring is attached to one of the pole the satellite and the effective cross-section area becomes larger when the satellite is illuminated from inclined angles in summer and winter. This seasonal variation of the effective cross-section area results in a semi-annual variation of the C_R estimates. The other is that the difference of optical reflectivity between its equatorial region and the polar regions are found to be more than the difference between the two polar regions.

Keywords: satellite laser ranging, solar radiation pressure, Ajisai

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