MRD 193- YORP

Data Product Overview

The absorption and reemission/reflection of sunlight creates a thermal torque that can modify the rotation rates and obliquities of small bodies known as the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect.

Overview

Using sufficient astronomical observations, one can determine both the sidereal rotation period and orientation of rotation poles for small bodies in the Solar System. In principle, the solution to both components may reveal secular effects due to the YORP torques. However, YORP torques are extremely weak. Fortunately, it is relatively straightforward to get an accurate determination of the rotation period of an asteroid, thereby allowing direct determination of the YORP effect over sufficiently long time intervals. Here the rotation rate and spin pole orientation of Bennu will be determined to precise accuracy. The measurement of both quantities is described elsewhere in this document. These data will be added to previous measurement of the rotation rate of Bennu using (i) optical photometry, and (ii) radar. A time series of this relative configuration might be, after appropriate geometric transformations are taken into account, transformed into a time dependence of the rotation phase ϕ of the body in the inertial space ("sidereal rotation"). If the body rotated about the principal axis of the inertia tensor with frequency ω, ϕ would be linear function of time, i.e. $\phi=\omega t+C$. The YORP effect contributes in $d\omega/dt$ by a non-zero average (secular term) and periodic terms. The latter are, however, typically too small to be detected, so the basic perturbation produced by the YORP effect is a quadratic advance in the sidereal phase of rotation $\Delta\phi=12(d\omega/dt)(\Delta T)2$ in time ΔT.

Note that a detection of YORP on Bennu may not be possible during the mission itself, but the data obtained can be combined with the earlier Earth-based observations to refine the currently measured value based on Earth observations. Also, should Bennu be in an excited spin state the measurement will be generalized to incorporate complex rotation and would provide insight into YORP for an excited body.

The data type is a value of $d\omega/dt$ calculated from rotational data as described above.

This will satisfy MRD-193

The observations required to provide the input data needed to make the data product will come from (i) the calculation of the rotational period and spin pole orientation calculated by the team (described elsewhere) and (ii) codes that can quantify the quadratic advance in the sidereal phase of rotation of Bennu.

The measurements will be most useful when the spacecraft is close enough to Bennu to provide accurate rotation data.

The data product has been already estimated and can be improved during the encounter phase. The more data added over time, though, the more precisely we are able to detect YORP, providing a fundamental constraint for modeling activities that will try to use the measured Bennu model to understand the physics of the YORP effect. The calculation itself takes little time, but dealing with errors, etc. and getting an accurate estimate make take weeks-months.

This product can be considered science value and long term science, but does not assist in sample site selection. The data type will consist of spin rate at a specified epoch, acceleration of the spin rate, and a precise determination of the spin pole and rate of change in the spin pole at a specified epoch. The data format will be general enough to allow for estimates of these quantities at several epochs across the encounter period. These measurements are derived by performing a joint estimate of the OSIRIS-REx spacecraft, the Bennu mass and gravity field, and the Bennu spin state across the entire encounter period. Data needed will be all of the tracking, imaging and lidar data required for other radio science data products. Note that only select periods of superior tracking data and geometry will be used in the estimation. The final data product will be generated at the end of the encounter phase, and due to the many tracking periods to be incorporated may require at least a month of activity.

Data Product Structure and Organization, Data Format Description

The final product will be the changes in the spin rate over time and spin pole over time. The format for this data is an ASCII file defined in detail in the RSWG SIS.

Data Product Generation and Validation

This product will be developed by Co-Is Dan Scheeres and Jay McMahon. Both will use preexisting codes to do this work. The work will be submitted to the OSIRIS-REx science team and peer review journals as a means to check the results

Data Flow and Standards

The data flow and standards for this calculation is the same as used for the main RSWG product of gravity field coefficients.