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Rotational study of 67P/Churyumov-Gerasimenko

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Abstract

The aim of the study is to determine the gravity field and moments of inertia along the principal axes of the comet, the obliquity of the axis of rotation with respect to the mean orbital plane, the precession rate, and the nutation coefficients. We also investigate the role of relevant parameters on the rotation.

1. Introduction

In Sierks et al. (2015) the nucleus structure and activity of comet 67P/Churyumov-Gerasimenko have been investigated based on data of the OSIRIS scientific imaging system on board the Rosetta space-craft. The authors found no obvious evidence for complex rotation of the comet nucleus and were able to constrain any motion of the spin-axis to $< 0.3^{o}$ over 55 days. In this work we predict complex motion of the spin axis of 67P/Churyumov-Gerasimenko over the comet's orbital period of 6.4 years, which is in agreement with the bounds given by Sierks et al. (2015), namely in terms of the precession rate and nutation coefficients of the comet's spin axis based on a rigid body approximation.

2. Methods

The gravity field and moments of inertia are derived from a polyhedron model, which is provided by the OSIRIS and NAVCAM experiments on Rosetta, and assuming constant density and volume of the comet. We calculate the obliquity of 67P with respect to the mean orbit, the precession rate and the nutation coefficients from rigid body theory (Kinoshita 1977).

3. Preliminary results

The 2nd degree denormalized Stokes coefficients turn out to be $C_{20} = -6.74 \times 10^{-2}$, $C_{22} = 2.60 \times 10^{-2}$. These values are consistent with normalized principal moments of inertia $A/MR^2 \simeq 0.13$, $B/MR^2 \simeq 0.23$ for normalized polar moment of inertia c equal $C/MR^2 \simeq 0.25$. The obliquity between the rotation axis and mean orbit normal is $\varepsilon \simeq 52^{o}$, the precession rate becomes $d\psi/dt \simeq 24\ ''/y$. Oscillations in longitude turn out to be of the order of $\Delta\psi \simeq 1\ '$, oscillations in obliquity are of the order of $\Delta\varepsilon \simeq 0.5\ '$. A parametric study of the precession rate in polar moment of inertia c can be found in Figure 1.

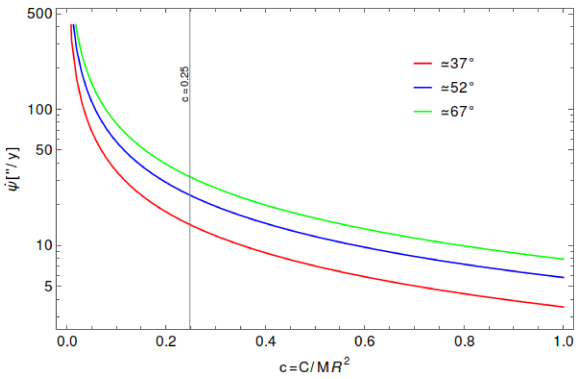

Figure 1: Mean constant precession rate of 67/P for $\varepsilon=52^{o}$ with an offset of $\pm 15^{o}$ for different polar moments of inertia c.

4. Summary and Conclusions

We provide important rotational parameters and a new gravity field solution, based on a rigid body approximation, that allow to validate possible interior structure models of comet 67P/Churyumov-Gerasimenko.

References

[1] Kinoshita, H. 1977, Cel. Mec., 15, 277.

[2] Sierks, H., Barbieri, C., Lamy, P. L., et al. 2015, Science, 347