EPSC Abstracts
Vol. 8, EPSC2013-580, 2013
European Planetary Science Congress 2013

67P/Churyumov-Gerasimenko physical parameters determination based on CONGO model, a physical and dynamical model.

L. Maquet (1,2), F. Colas (2), L. Jorda (3) and J.Croviser (1)

(1) LESIA, Observatoire de Paris, France (contact : lucie.maquet@obspm.fr), (2) IMCCE, Observatoire de Paris, France, (3) LAM, Marseille, France.

Abstract

We present here the CONGO model for COmetary Non-Gravitational Orbits. The method is based on the modeling of the nucleus surface in several strips located at different latitudes. The contribution of each strip to the overall NGF and the density of the nucleus are fitted from the astrometric and photometric measurements. We applied this model to 67P/Churyumov-Gerasimenko, target of Rosetta mission.

1. Introduction

CONGO (COmetary Non Gravitational Orbit) [1] is a method based on a new approach to model cometary non-gravitational forces and accelerations our aim is to determine physical parameters of the nucleus and also more reliable ephemeris. We applied this method to the comet 67P/Churyumov-Gerasimenko, target of the Rosetta mission. We determined the fraction of active area, the rotational axis orientation, the mass and the density of the nucleus. These parameters are important for the success of the mission.

2. The method

CONGO is a physical and dynamical model taking into account the non-gravitational forces due to the water outgassing from the nucleus.

Hypothesis: Our goal is to have a simple but realistic model without too many parameters like Sekanina [2] The nucleus is modeled as a triaxial ellipsoid divided into latitudinal bands (Fig. 1), in fact we just average the non gravitational forces during one nucleus rotation which is always short compare to the orbital revolution.

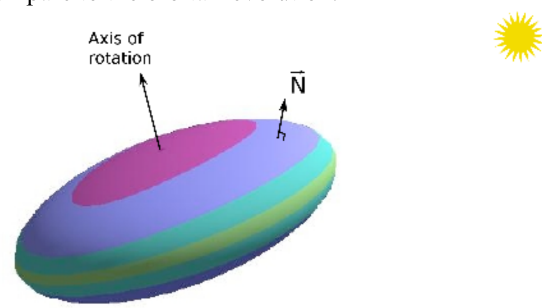

Figure 1: Geometrical view of a modeled nucleus with seven latitudinal strips.

The latitude is defined as the angle between the normal to the surface of the ellipsoid and a plane perpendicular to the nucleus rotational axis.

The thermal inertia is neglected and the gas velocity is considered proportional to the thermal gas velocity. These hypotheses allow seasonal effects.

Calculations of the total acceleration: The non-gravitational acceleration (NGA) depends on the nucleus mass and on coefficients (C_i) relating to the activity of each band (C_i=0 if the band is not outgassing and C_i=1 if the whole band is outgassing). It depends also on the surface of the bands, the water sublimation rate, the velocity and the mass of the ejected molecules. The total NGA is a linear combination of the NGAs of each band.

From astrometrical measurements, we can fit the ratios Ci/M_C, where M_C is the mass of the nucleus. To determine the total NGA, we also calculate the total water production rate as a linear combination of the water production rate of each band. We can optimize the coefficients C_i from water production rate measurements. From the ratio C_i/M_C and the coefficient C_i, we can deduce the mass of the nucleus so the density if we know the volume. We remark that the total NGA depends on the orientation of the rotational axis, we have made a X^2-map in relation with the direction of the rotational axis.

3. Results on 67P/Churyumov-Gerasimenko

Fit of the astrometrical measurements: We determined the physical parameters with a model based on three bands. After fitting the astrometrical measurements, we found a reduced- X^2 equal to 1.04, it is better than the one computed with Marsden et al. [3] model.

Determination of the position of the rotational axis: From the X^2-map (figure 2), we found that the optimal axis of rotation is (α=150°±25°,δ=25°±25°) or (α=330°±25°,δ=-25°±25°) which correspond to the same solution with a opposite direction of rotation.

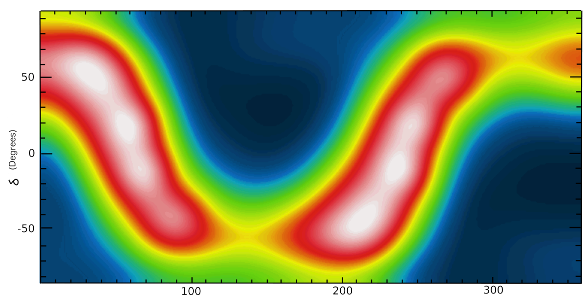

Figure 2: X^2-map for the determination of the rotational axis (blue areas are low value of X^2 and white areas are high value of X^2)

Determination of the mass and of the nucleus density: Thanks to the water production rates measurements, we deduce that the nucleus is more active at low latitudes (on the equatorial band). Moreover, we have obtained a measurement of the nucleus mass: $3.14 \times 10^{12} \pm 0.21 \times 10^{12}$ kg. This mass corresponds to a density equal to 102±9 kg m^{-3}. This determination is consistent with those obtained by other authors ([4], [5]).

References

[1] Maquet, L., Colas, F., Jorda, L. and Crovisier, J.: CONGO, model of cometary non-gravitational forces combining astrometric and production rate data. Application to comet 19P/Borrelly, A&A, Vol. 548, pp. A81, 2012.

[2] Sekanina, Z.: A model for comet 81P/Wild 2, Journal of Geophysical Research, Vol. 108, Issue E10, pp. SRD 2-1, 2003.

[3] Marsden, B.G., Sekanina, Z., Yeomans, D.K.: Comets and nongravitational forces. V, Astronomical Journal, Vol. 78, p. 211, 1973.

[4] Davidsson, B.J.R. and Gutiérrez, P.J.: Nucleus properties of Comet 67P/Churyumov Gerasimenko estimated from non-gravitational force modeling, Icarus, Volume 176, Issue 2, p. 453-477, 2005.

[5] Rickman, H.,Kamel, L., Festou, M.C., Froeschlé, Cl.: Estimates of masses, volumes and densities of short-period comet nuclei, in ESA, Proceedings of the International Symposium on the Diversity and Similarity of Comets p 471-481, 1987